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INTERMOUNTAIN STATION
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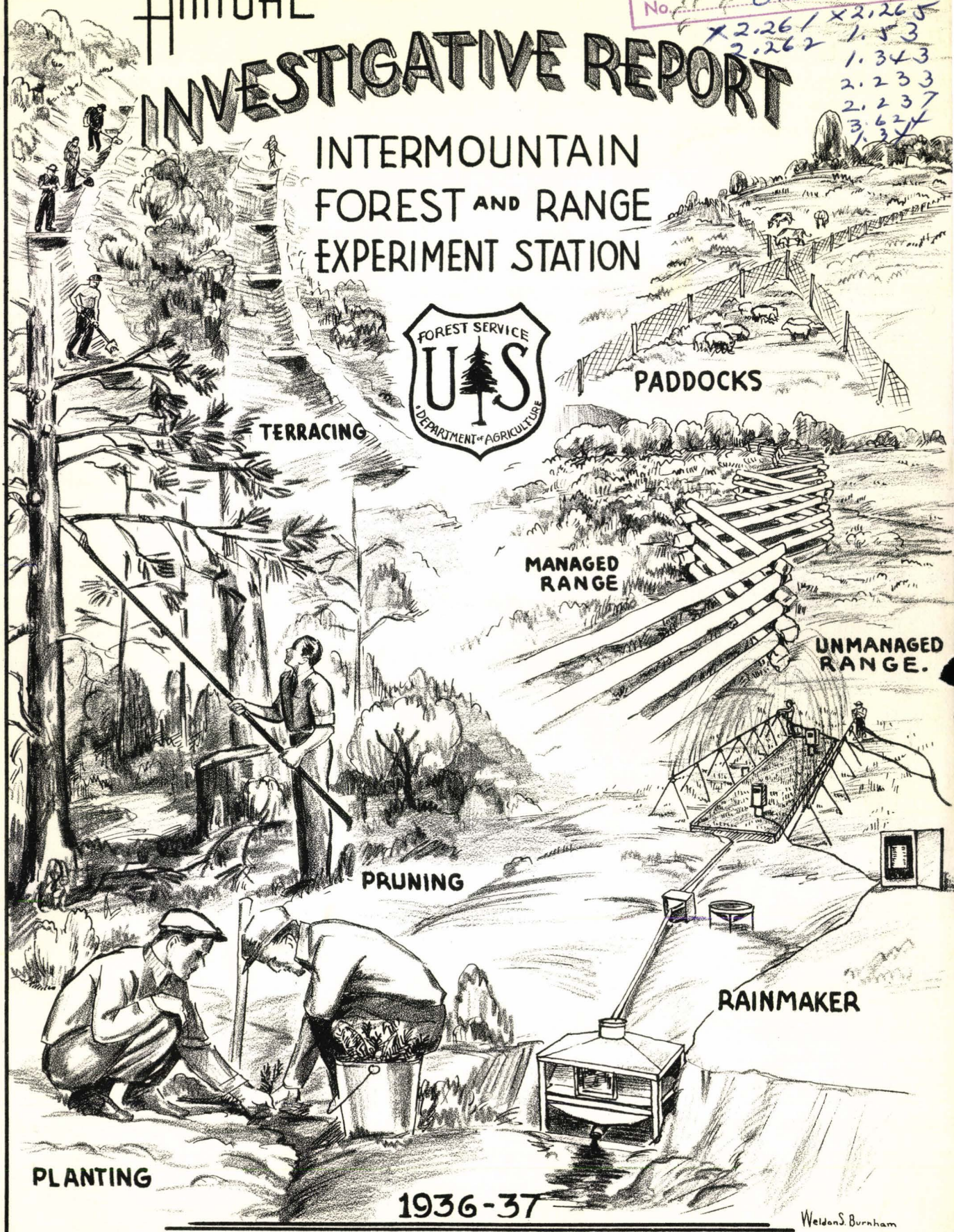
ANNUAL INVESTIGATIVE REPORT

INTERMOUNTAIN FOREST AND RANGE EXPERIMENT STATION

FOREST SERVICE U S DEPARTMENT OF AGRICULTURE



1936-37

Weldon S. Burnham

R - INT
Investigative Program

March 12, 1937

ANNUAL INVESTIGATIVE REPORT

INTERMOUNTAIN FOREST AND RANGE EXPERIMENT STATION

1936 - 1937

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PART I. INTRODUCTION

PART I. INTRODUCTION

This 1936-37 annual report presents a number of new features, which have a twofold purpose: First, in preparing these sections it was necessary for the staff to analyze, evaluate and summarize the problems of wildland management and the results of past and current investigations. This gave us a clearer picture of our research requirements and the strength and weaknesses of our program. Second, here we have a summary of pertinent information which can be used to inform those people who are interested in our work and station and are entitled to know of our plans and accomplishments.

Part I contains, first, a physiographic map showing the geographic location of our branch stations and work areas. Second, a series of charts presenting the station personnel and their assignments and the organization of our work and the break-down of the projects. Part II gives in brief a statement of our forest, range and influence problems and the degree to which the research program and facilities are gaged to arrive at a solution of these problems. Part III is a brief statement outlining the past contributions from each major division. Part IV briefly describes what we consider our outstanding current accomplishments. Part V is a review of our efforts in presenting to the public by means of field days, tours, and inspections the problems of research and the results of our investigations. Parts VI, Plans and Needs, VII, Current Publications and Manuscripts, VIII, Project Summaries, follow the procedure of other years, and have been prepared as a supplementary statement for official use only and are not available for distribution.

STATION ORGANIZATION - 1937

ADMINISTRATIVE

Regular	Reed W. Bailey	Director
	Walter E. Mann	Adm. Assistant

CLERICAL

Regular	Marguerite A. Israelson	Clerk
	Herbert Burrell	Clerk
	Leona H. O'Donnell	Asst. Clerk
Emergency	Willard M. Chase	Asst. Clerk
	Zura Gerdicia	Jr. Stenographer
	Ben Merrill	Jr. Clerk
	Bernice Bradley	Under Clerk Typist
	Eugene Van Zweden	Under Clerk
	Milo H. Lowder	Asst. Clerk

DRAFTING

Emergency	Byron F. Thurmond	Prin.Engr.Draftsman

EDITORIAL

Emergency	Wilford D. Porter	Senior Editor

LABORATORY

Emergency	Lowell Woodward	Jr. Range Examiner
	Robert W. Parry	Jr. Chemist

LIBRARY

Regular	Signe Ruh Ottersen	Librarian (Coop. R-4)

FOREST MANAGEMENT (Silvical Research)

Regular	T. Ewald Maki	Asst. Forester
	Edwin L. Mowat	Asst. Silviculturist
Emergency	Donald E. Cox	Jr. Forester
	William J. B. Collins	Asst. to Technician
	Edmond L. Barraclough	Jr. Asst. to Technician

RANGE MANAGEMENT INVESTIGATIONS

WINTER RANGE

Regular	George Stewart	Sr. Forest Ecologist
	Selar S. Hutchings	Asst. Range Examiner
Emergency	Perry Plummer	Jr. Range Examiner
	John Quayle	Asst. to Technician
	Hosmer R. Bjarnson	Jr. Asst. to Technician

SPRING-FALL RANGE

Regular	George Stewart	Sr. Forest Ecologist
	Joseph F. Pechanec	Asst. Range Examiner
Emergency	Harold E. Gibson	Asst. to Technician
	Eldon Earl Meik	Jr. Asst. to Technician
	Bernard C. Christian	Jr. Asst. to Technician

SUMMER RANGE-WASATCH PLATEAU

Regular	George Stewart	Sr. Forest Ecologist
	Raymond Price	Assoc. Range Examiner
Emergency	Reed Huff	Jr. Asst. to Technician

ARTIFICIAL RESEEDING

Regular	George Stewart	Sr. Forest Ecologist
	Rudger H. Walker	Conservationist
	C. Kenneth Pearse	Assoc. Range Examiner
	Raymond Price	Assoc. Range Examiner
	Ira Clark	Asst. Conservationist
Emergency	Alvin C. Hull	Jr. Range Examiner
	Gerard J. Klomp	Jr. Range Examiner
	Henry E. Peterson	Asst. to Technician
	Joe M. Cutler	Jr. Asst. to Technician

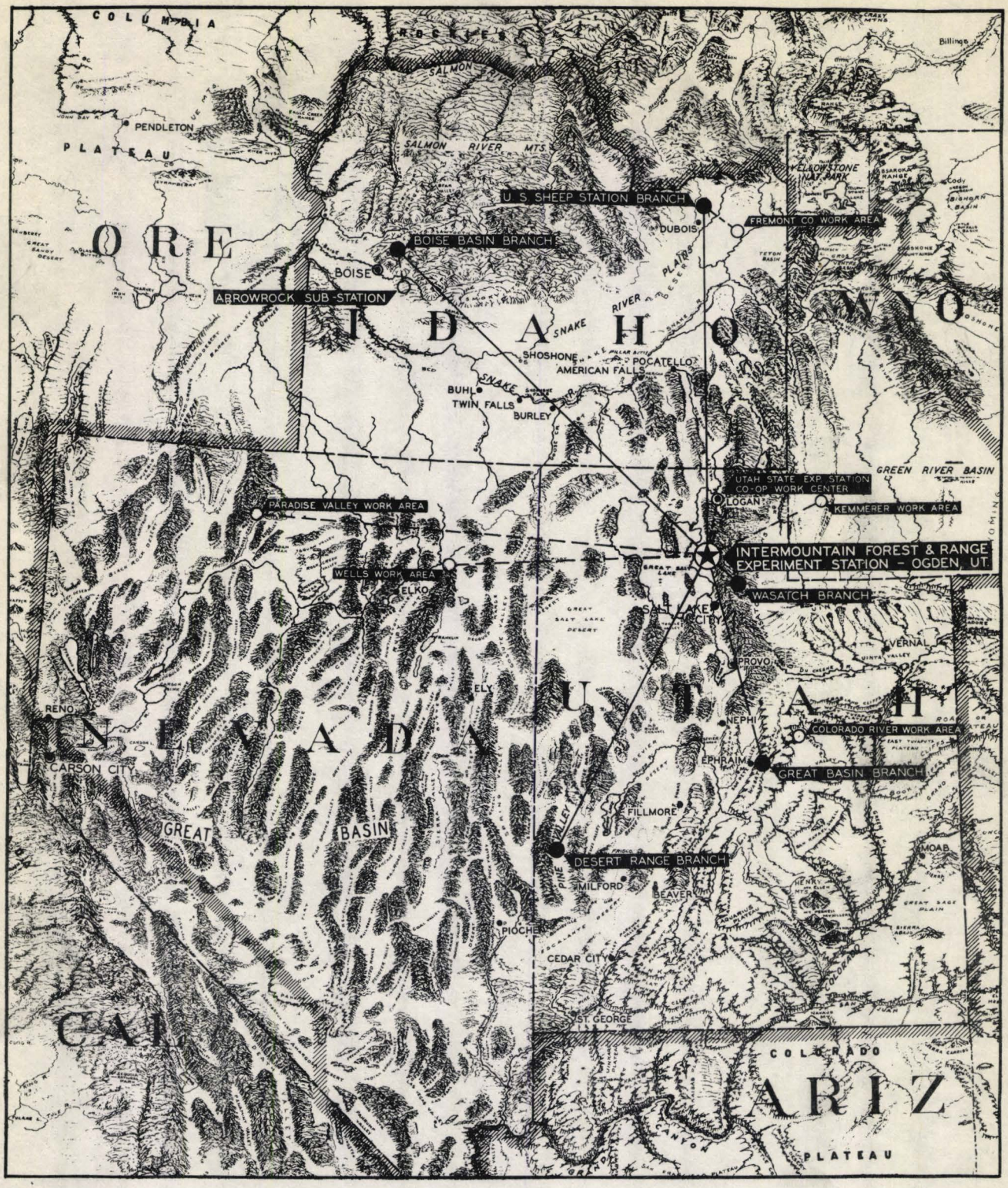
FOREST INFLUENCE INVESTIGATIONS

GREAT BASIN AND COLORADO PLATEAU (UTAH) EROSION

Regular	George W. Craddock	Sr. Range Examiner
	A. Russell Croft	Assoc. Conservationist
Emergency	Howard E. Petersen	Jr. Range Examiner
	Howard R. Foulger	Asst. to Technician
	Dean A. Anderson	Asst. Range Examiner
	Harry W. Pledger	Foreman C & M
	Lemuel H. Thompson	Jr. Asst. to Technician

BOISE (GRANITIC SOILS) EROSION

Regular	George W. Craddock	Sr. Range Examiner
	C. Kenneth Pearse	Assoc. Range Examiner
Emergency	Reuben I. Campbell	Jr. Eng. Aide
	Dilworth Harper Marchant	Jr. Range Examiner
	Neil Wilcox	Jr. Asst. to Technician



MAP OF THE INTERMOUNTAIN REGION

SHOWING LOCATION

OF

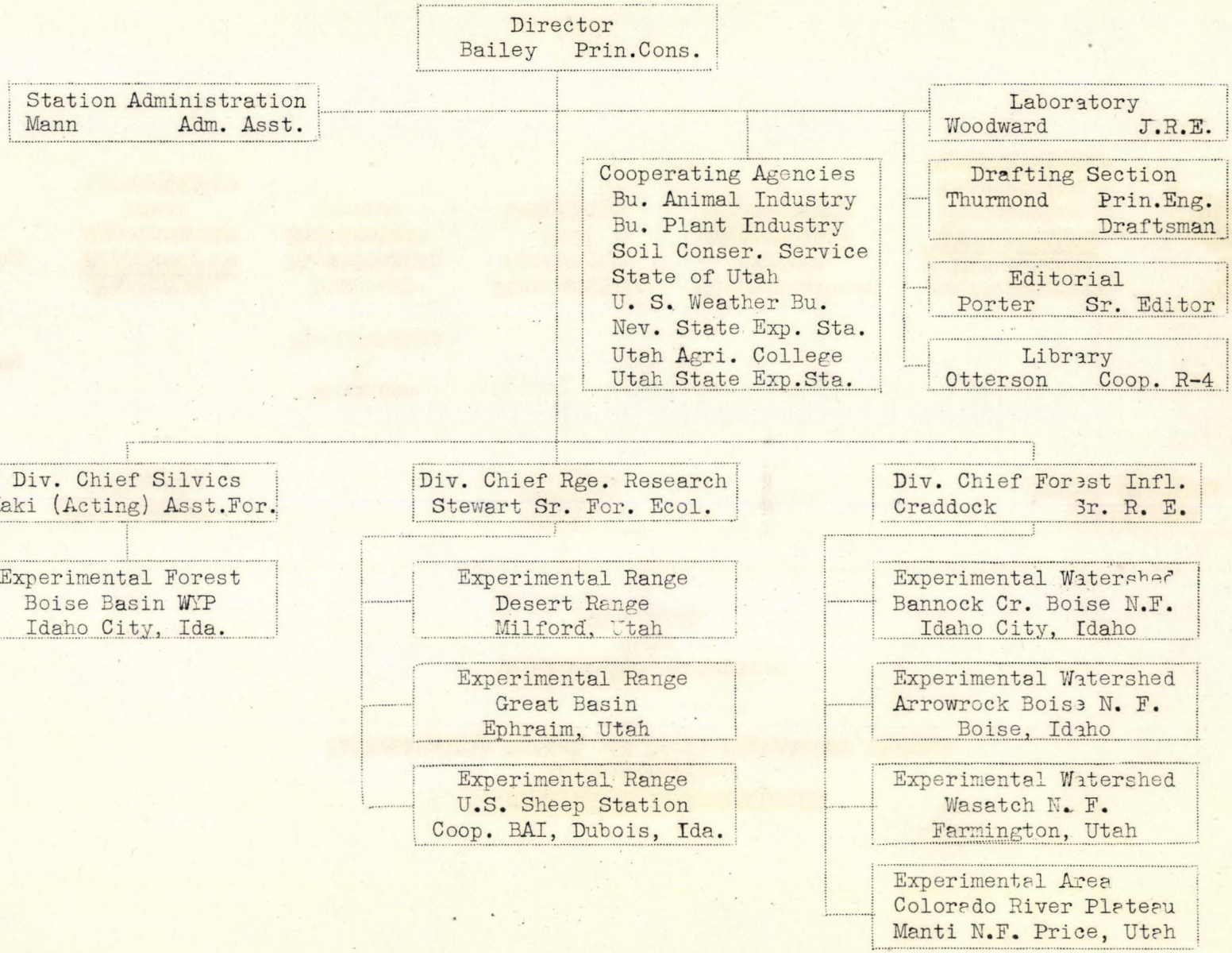
HEADQUARTERS, BRANCH STATIONS AND WORK AREAS

OF THE

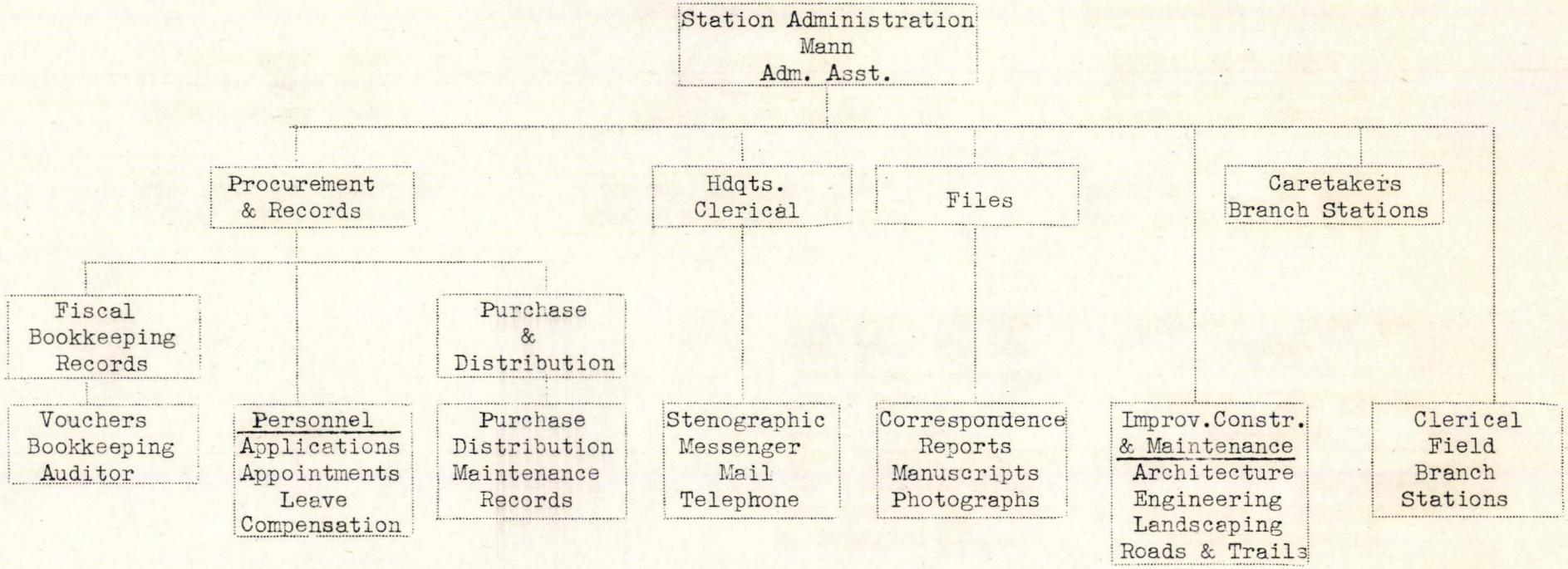
INTERMOUNTAIN FOREST & RANGE EXPERIMENT STATION

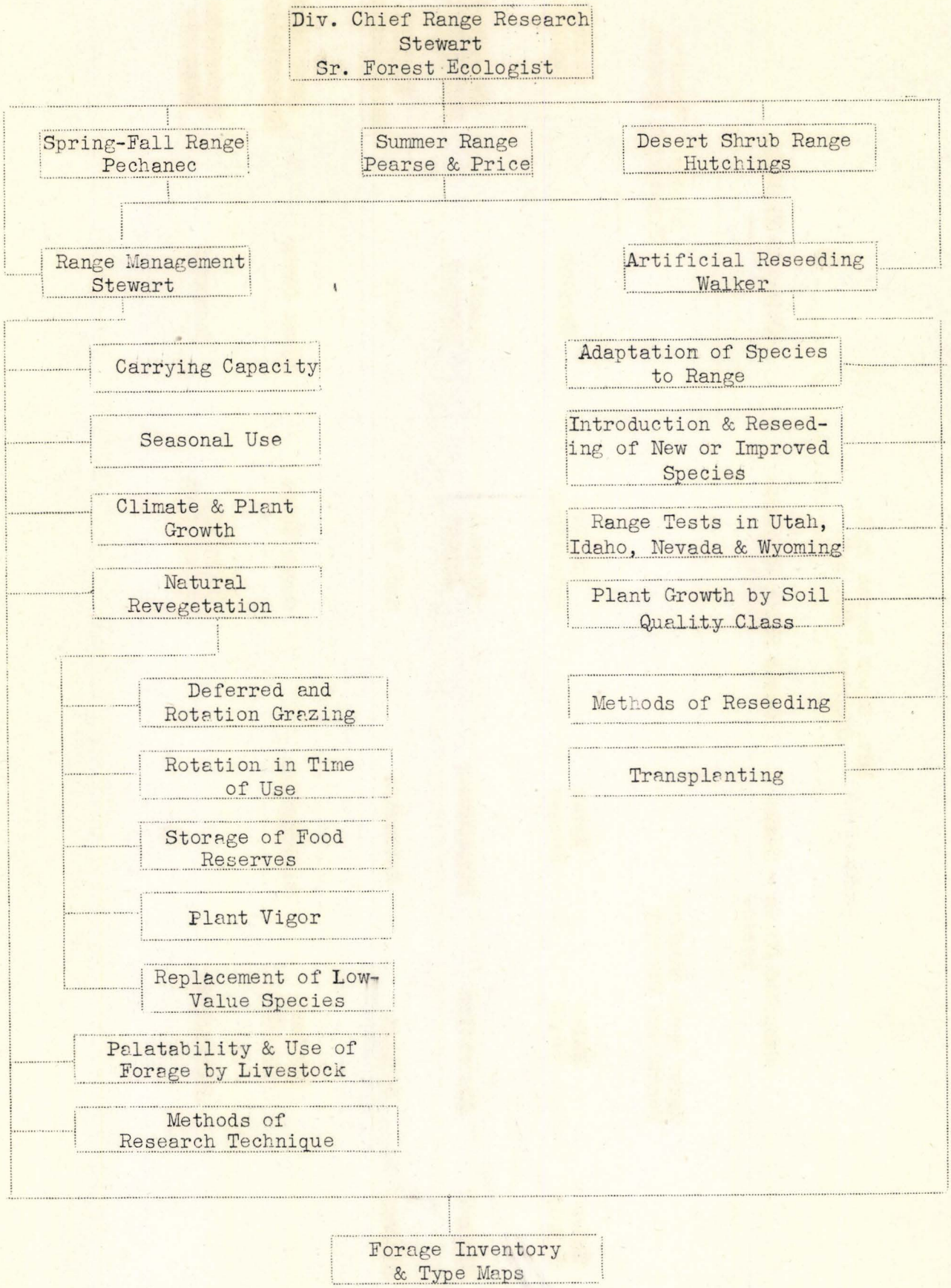
FOREST SERVICE U.S.D.A.

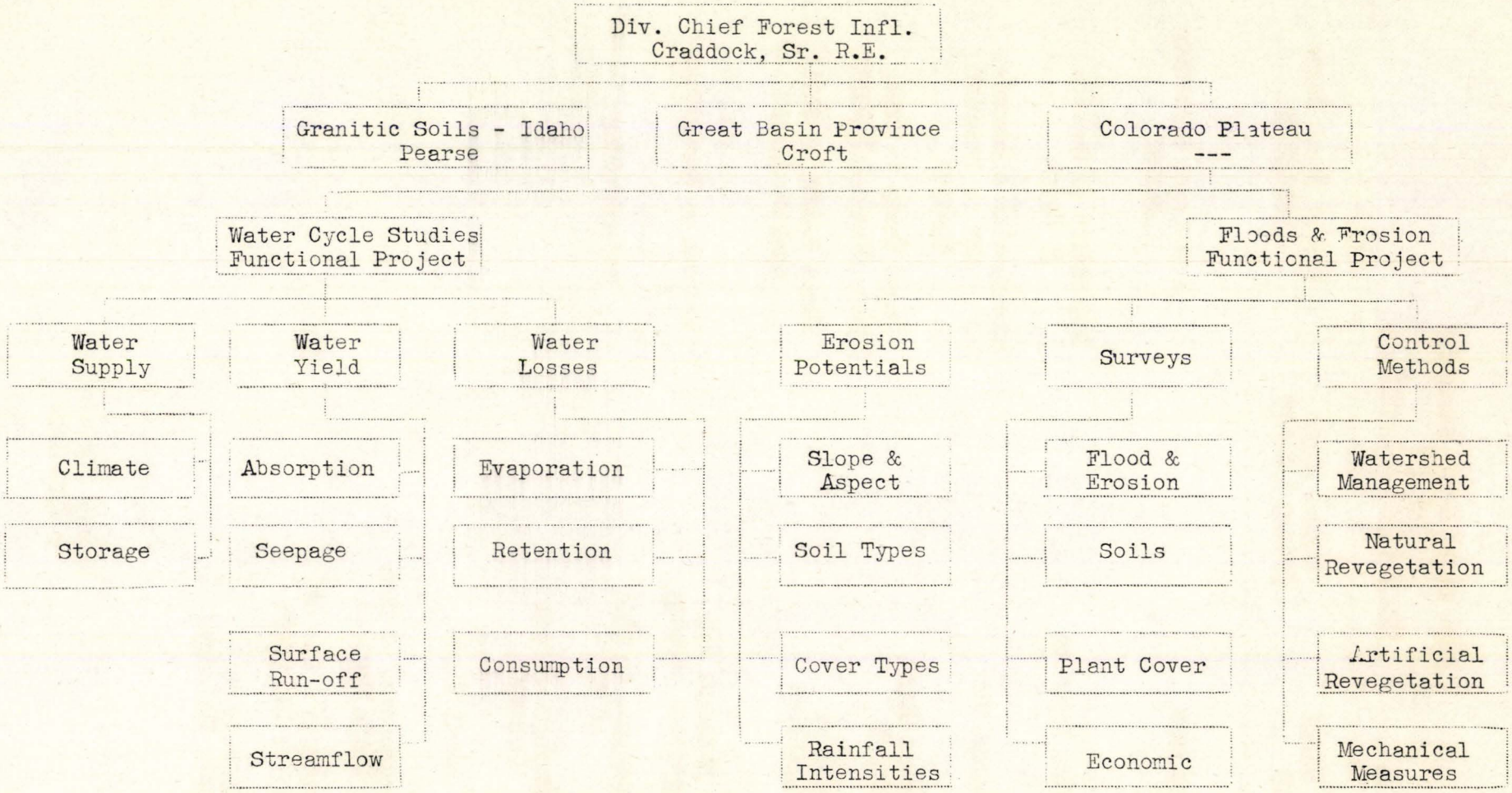
U. S. DEPARTMENT OF AGRICULTURE
Forest Service
Intermountain Forest and Range Experiment Station



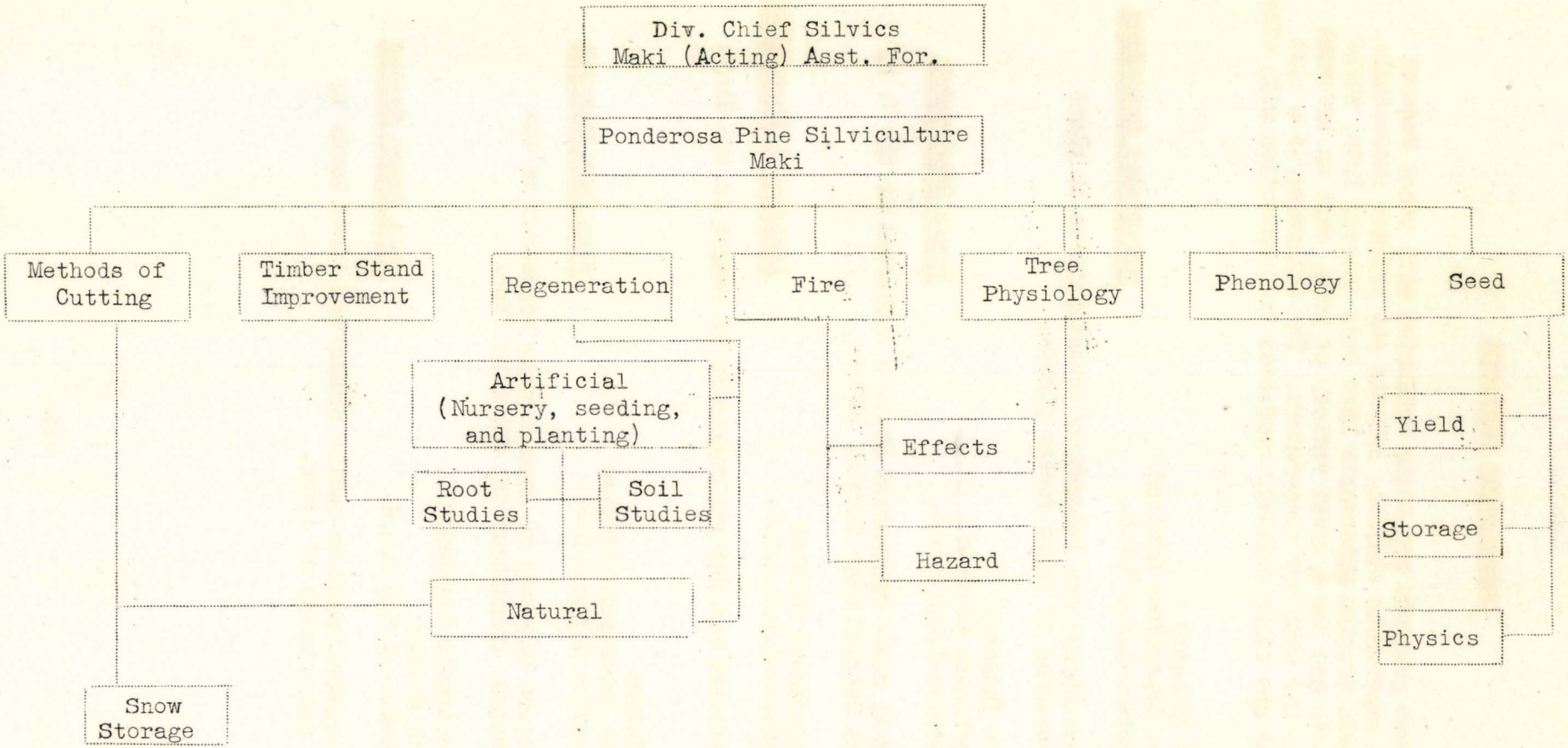
U. S. DEPARTMENT OF AGRICULTURE
Forest Service
Intermountain Forest and Range Experiment Station




Div. Chief Range Research
Stewart
Sr. Forest Ecologist
Spring-Fall Range
Pechanec
Summer Range
Pearse & Price
Desert Shrub Range
Hutchings
Range Management
Stewart
Artificial Reseeding
Walker
Carrying Capacity
Seasonal Use
Climate & Plant Growth
Natural Revegetation
Deferred and Rotation Grazing
Rotation in Time of Use
Storage of Food Reserves
Plant Vigor
Replacement of Low-Value Species
Palatability & Use of Forage by Livestock
Methods of Research Technique
Adaptation of Species to Range
Introduction & Reseeding of New or Improved Species
Range Tests in Utah, Idaho, Nevada & Wyoming
Plant Growth by Soil Quality Class
Methods of Reseeding
Transplanting
Forage Inventory & Type Maps


Div. Chief Forest Infl.
Craddock, Sr. R.E.
Granitic Soils - Idaho
Pearse
Great Basin Province
Croft
Colorado Plateau

Water Cycle Studies
Functional Project
Floods & Erosion
Functional Project
Water Supply
Water Yield
Water Losses
Erosion Potentials
Surveys
Control Methods
Climate
Storage
Absorption
Seepage
Surface Run-off
Streamflow
Evaporation
Retention
Consumption
Slope & Aspect
Soil Types
Cover Types
Rainfall Intensities
Flood & Erosion
Soils
Plant Cover
Economic
Watershed Management
Natural Revegetation
Artificial Revegetation
Mechanical Measures


Div. Chief Silvics
Maki (Acting) Asst. For.
Ponderosa Pine Silviculture
Maki
Methods of Cutting
Timber Stand Improvement
Regeneration
Fire
Tree Physiology
Phenology
Seed
Artificial (Nursery, seeding, and planting)
Root Studies
Soil Studies
Natural
Snow Storage
Effects
Hazard
Yield
Storage
Physics

COOPERATIVE PROJECTS

Cooperative projects are being conducted with other Federal agencies, state experiment station, schools and private individuals. For major projects written agreements have been entered into, while for minor projects and for a great variety of work, only an informal understanding is had with our cooperators. The following is a list of projects that are being actively conducted in cooperation with other agencies:

Bureau of Plant Industry
Utah Agriculture Experiment Station
U. S. Forest Service-I.F.& R.E.S. — Artificial Reseeding

Field, greenhouse and laboratory investigations in plant breeding and reseeding of range forage plants.

Bureau of Animal Industry
U. S. Sheep Experiment Station
U. S. Forest Service-I.F.& R.E.S. — Range Management

Spring-fall range management studies conducted at the U. S. Sheep Experiment Station near Dubois, Idaho.

Nevada State Experiment Station
U. S. Forest Service-I.F.& R.E.S. — Artificial Reseeding

The artificial and natural reseeding of ranges in the State of Nevada.

U. S. Weather Bureau
Utah Agriculture Experiment Station
U. S. Forest Service-I.F.& R.E.S. — Utah Snow Surveys

This project consists of snow surveys conducted on the principal watersheds throughout the State of Utah.

Bureau of Agricultural Economics
Utah Agriculture College
U. S. Forest Service-I.F.& R.E.S. — Utah Range Survey

Range reconnaissance on public domain and state lands to ascertain type and percent of cover.

Bureau of Agricultural Economics
University of Idaho
U. S. Forest Service-I.F.& R.E.S. — Idaho Range Survey

Range reconnaissance on public domain and state lands to ascertain type and percent of cover.

Bureau of Agricultural Engineering
Boise River Waterusers
U. S. Forest Service-I.F.& R.E.S. — Snow Surveys

Survey of the snow cover on the headwaters and principal tributaries on the Boise River.

Jackson Brothers
Walter Jones
Jesse Guymon
Fountain Green Woolgrower's Assoc. — Range Management

Owners of sheep used in cooperative range management studies at the Desert Range Branch Station.

PART II. SPECIAL DISCUSSIONS

PART II. SPECIAL DISCUSSIONS

A. INTERMOUNTAIN RANGES

More than five million sheep and one million cattle depend on the ranges of the Intermountain region for 40 to 95 percent of their entire feed supply. These range livestock produce approximately 50 percent of the direct agricultural income of the region, and contribute indirectly to fully half the remainder. A large part of the business of about 60 supply towns and larger trade centers such as Salt Lake City, Ogden, Reno, Boise and Pocatello is also derived from the range industry. Owing to the fluctuating and uncertain production of range forages and to instability in economic conditions, the range business of a large proportion of the stockmen wavers back and forth, often hovering near the edge of bankruptcy.

1. Agencies that Promote Instability

Drought, range depletion, and the recent economic depression have all contributed in a major way to this state of instability. From 1930 to 1935 all three of these forces operated simultaneously in a cumulative manner. As a result, during this period heavy losses have been suffered in both cattle and sheep. For example, sheep in the vicinity of the Desert Range Branch Station in western Millard County, Utah, suffered annual death losses of 15 percent, and lamb crops dropped to an average of only 57 percent in spite of the 32 pounds of concentrate supplements fed to each ewe. Individual outfits lost 30 to 60 percent of the sheep and incurred high expenses for supplemental feeding.

The root of the trouble is that the ranges, except on the national forests, no longer produce the valuable grasses they once did. Other forage plants also possess only 20 to 80 percent of the vigor they normally had and, in many areas of great livestock concentration, nearly half the plants are dead. One of many examples of this occurs in Wah Wah Valley in Beaver County, Utah where heavy grazing during drought caused the death of 89 percent of the ricegrass plants, whereas, conservative grazing during the same drought killed only 20 percent. A forage inventory of Utah made piecemeal between 1932 and 1936 showed these conditions to be widespread.

This widespread mortality of valuable native forages, together with reduced size of the live plants as a result of lessened vigor has left in the plant cover spaces immediately occupied by aggressive species of low-forage value. On extensive areas of sagebrush foothill and valley ranges, Russian-thistle and cheatgrass occupy the range almost completely. On the winter ranges the valuable white sage and ricegrass have, over large range units, given way to matchbrush and desert rabbitbrush, two plants of little forage value. On spring-fall ranges, sagebrush has greatly increased where bunchgrass, once abundant, is now almost absent. Throughout the whole Intermountain

region, the low-value, short-season cheatgrass has replaced both sagebrush and the valuable bunchgrass in the foothill zone. Forage inventories of localized areas show that in Idaho, Nevada, and western Wyoming the same conditions exist qualitatively, but because nothing that approximates a quantitative forage inventory has been made, information, except for Utah, is fragmentary.

2. Range Industry Hedged with Problems

To grapple with these serious and far-reaching problems is being attempted by the Intermountain Forest and Range Experiment Station. In order to do this with reasonable effectiveness, whole reservoirs of new information must be acquired by research.

Accurate and comprehensive forage inventories are needed to furnish basic data on which to construct grazing plans and practices that will lead to range rehabilitation and forage maintenance. Seasonal growth inventories, especially on winter ranges, would permit in the fall an intelligent planning of the winter livestock operation.

With wholesale changes in the plant cover in rapid progress, the demand for palatability inventories will be high; for example, on the relative value of cheatgrass, Russian-thistle, and desert rabbitbrush and matchbrush as compared with the replaced native forages. Another outstanding need is knowledge of the time and intensity of utilization that various forage plants can withstand without injury.

It is not known how large range livestock outfits must be in order to be profitable economic units, either by themselves or in combination with crop growing. Nor can the economic relations of range, livestock production, dry-farming, and irrigation with rural life in the West as a whole be overlooked.

The planning for utilization and administration of range resources is so intricately related to all phases of life in western United States, that knowledge must be increased regarding the principles underlying natural revegetation, non-destructive plant utilization, systems of grazing management, induced plant replacement by burning or otherwise removing sagebrush, reseeding or transplanting on range units of critical importance, sources of seed supply, control of injurious plants, and the search for new or improved forage species. A number of these problems are being investigated by the Intermountain Forest and Range Experiment Station, but many highly important investigations are yet awaiting to be undertaken, such as: (1) forage inventories in Idaho, Nevada, and western Wyoming; (2) a regular program of seasonal growth inventories and balance in the forage supply for livestock; (3) revegetation on some 8 to 12 vegetative types not included in present studies, including the replacement of cheatgrass by the good perennial forages; (4) feasibility of the controlled burning of sage and other brush under several conditions and the practicability of reseeding burned areas; (5) artificial reseeding on unfavorable and intermediate sites; (6) obtaining and testing range

plants that to the present have been untried; (7) relation of natural and artificial revegetation to the quality and depth of soil; (8) time and intensity of utilization that forage plants can withstand without injury; (9) methods of water distribution, especially on desert ranges; and (10) systematic methodology of studying native vegetation.

3. Problems Now Being Investigated

Evidently many problems must be solved before a comprehensive and effective program of rehabilitation can be launched. The limited personnel and budget of the Intermountain Forest and Range Experiment Station have narrowed the field of endeavor to four major projects; namely, (1) summer range, (2) sagebrush-grass spring-fall range, (3) winter range, and (4) reseeding.

The project dealing with summer range problems has headquarters in Ephraim Canyon in central Utah. The one on sagebrush-grass spring-fall range is "housed" at the U. S. Sheep Experiment Station near Dubois, Idaho and is conducted in cooperation with the Bureau of Animal Industry. Headquarters for the winter range major project is at the Desert Range Branch Station, 50 miles west of Milford, Utah. The artificial reseeding project is operated from Ogden, Utah, but has field trial centers near Boise and Dubois, Idaho; near Wells and Paradise Valley, Nevada; near Ephraim and Bountiful, Utah; and, in a smaller way, near Kemmerer, Wyoming. One critically important phase of the reseeding project deals with plant breeding of forage grasses and is operated near Logan, Utah in cooperation with the Utah Agricultural Experiment Station and with the Bureau of Plant Industry. Two agents from the office of Forage Plants, Bureau of Plant Industry, are in resident charge of the breeding work.

The operating subprojects of the four major projects include studies on one vegetative type each for summer range in the high mountains of central Utah, for spring-fall range in the Upper Snake River plains, and for winter range in desert shrub valleys and hills of western Utah as follows:

(1) Relation of climate to plant growth; (2) natural revegetation studies under complete protection and under controlled grazing; (3) carrying capacity and seasonal use studies under actual grazing practices; (4) plant vigor and mortality studies; (5) artificial reseeding studies on the more promising sites; (6) effects of the controlled burning of sagebrush 15 miles north of St. Anthony, Idaho; (7) intermittent forage inventories in Utah; and (8) incidental studies in the development of methodology of range research.

Clearly, the range research program of the Intermountain Station ought to be enlarged because many urgent problems are crying for solution - problems that are wide in their scope, deep in their intensity, and far-reaching in their application.

PART II. SPECIAL DISCUSSIONS

B. MOUNTAIN WATER

Within the Intermountain region the agricultural, industrial and social enterprises of nearly a million people are concentrated in semidesert valleys where the success of all activities is dependent upon an adequate supply of water. This vital resource is derived almost entirely from streams that rise on the 45 million acres of mountainous lands which comprise the headwaters of the Snake, Great Basin and upper Colorado drainage systems. The 25 to 50 or more inches of precipitation that falls annually on these watersheds when delivered to the valleys as streamflow and subsequently diverted, is the life blood which makes useful the taps in homes, the turbines in power plants and the dry soil of fertile farms. Because of this dependence upon a supplemental water supply, it truthfully can be said that the several billions of dollars which have been invested in the developments of this inland empire are secured by a bond of mountain water.

From the time streamflow was first diverted and put to beneficial use in this region nearly 100 years ago, the fulfillment of ever increasing demands for water has been subject to serious problems which have arisen primarily out of the physiographic and climatic characteristics of the watersheds and the misuse of the organic resources on these lands. To understand these problems and the steps that must be taken for their control, it is essential to recognize the factors and principles underlying the problem. Certain of these are common to the region as a whole while others differ as to detail in each of the three major drainage basins.

Water is in greatest demand in the desert valleys of this region during the summer and fall when irrigation is needed to supplement deficiencies of soil moisture, and is needed least in the winter when cold temperatures prevent plant growth. Contrary to these needs, streamflow from the watersheds is at a peak during the spring when water that accumulates over winter in the snow field is liberated by warm temperatures, and ordinarily is at a low stage during the summer and fall after the soil and rock mantle of the mountain slopes are drained of free water. Obviously, these fundamental differences between water supply and demand constitute a serious limitation on the present, as well as the future, security of this intermountain civilization and warrant the application of every effort that is necessary to insure the delivery of adequate supplies of usable streamflow to the valley water users.

Normally limited steamflow is not, however, the only concern of water users in this region. In the first place, the watersheds for the most part are characterized by high gradient, deeply filled channels, steep canyon slopes and erosive soils, which physical features, as well as the rapid melting of snow in spring and the occurrence of

torrential summer storms, make them highly susceptible to flood. Moreover, due to the impairment by fire, overgrazing and logging of the restraining influence of the plant and soil mantle, accelerated run-off and erosion from critical portions of certain watersheds in each of the three major drainage basins have caused floods of unusable water, the silting of reservoirs and the damaging of other improvements which are necessary for making use of streamflow. These abnormal occurrences, together with precipitation deficiencies, increased demands for water and inadequate storage facilities, have tended to accentuate the seriousness of a naturally scant water supply and have emphasized the need for the rehabilitation and conservation of the watershed function of the mountainous lands.

In the Snake River drainage mountain water is required for irrigating 2-3/4 million acres of valley farms and for supplying about 250,000 people with power and culinary water. Streamflow for these purposes is derived primarily from high mountains that border the Snake River Valley on the north, east and south, although some run-off is also contributed from the lower foothills which lie between the mountains and the valley floor.

The upland areas are characterized by steeply sloping canyon walls, deeply filled channels and a forest cover that is highly susceptible to damage by logging and fire. Run-off from these areas normally is well regulated. Many localized areas have been burned, however, and from these places rapid run-off of melted snow in the spring contributes to the peak of streamflow when water is not greatly needed in the valleys. Moreover, during torrential summer storms water collects quickly on these areas to cause floods that rip out the deeply filled channels and add tremendous quantities of silt to the main streams.

The foothill lands are typified by a highly erosive soil and a naturally sparse covering of herbaceous and shrubby vegetation. Due to overgrazing and fire the original bunchgrasses over extensive areas have been displaced by annual plants which are particularly inefficient for regulating run-off and holding the soil in place. As a consequence, accelerated erosion is widespread and each year large amounts of soil are washed directly into the expensive reservoirs, diversion works and other improvements in the valleys to which the foothill lands are directly tributary.

In the Great Basin province many of the most intensively developed valley lands, as well as the largest cities and communities, are situated at the mouths of steep canyons along the Wasatch Front where water is available from the melting of winter snow and summer rains that fall on the headwater lands. The precipitation that accumulates on the steep brush- and timber-covered slopes of these mountains drains into boulder-filled channels of very high gradient which end in pronounced alluvial fans at the canyon mouths. At the lower elevations, especially in the Bonneville Basin, the canyon slopes are flanked with delicately placed deposits of sand and gravel that are highly erosive when disturbed.

The destruction of the vegetation by overgrazing, fire and timber cutting on small areas in the upper portions of these watersheds has resulted in devastating mud-rock flows from many of the steep canyons. Water from summer torrential storms instead of percolating slowly into and through the soil mantle to underground passages, collects on the surface of these "sore spots" - which may comprise less than 10 percent of the watershed area - and drains quickly into the stream channels. Here it forms torrents of sufficient volume and force to rip the channels to bedrock, creating a semiliquid mass of rock, mud and debris that is carried out and deposited on the valley floor. Mud-rock flows of this character have occurred with increased frequency and severity in recent years, not only causing damage of property but also taking a toll of human life.

In the Upper Colorado River Basin permanent streamflow is derived principally from high, generally well-covered mountains and plateaus. Water from these sources, however, does not become available for use on the 1,400,000 acres of irrigated lands within the upper basin or for storage, power and diversion in the lower basin until after it passes in deeply cut channels through successively lower and extensive plateaus of sedimentary formation. These lower areas are characterized by many barren rock cliffs and escarpments and by bench lands and valleys on which, since settlement, the vegetation has been seriously depleted by overgrazing. Run-off is exceptionally rapid from these lands during the melting of snow in spring and following summer storm, carrying with it not only the soil from the slopes but also enormous quantities of sand and clay from deeply filled valleys. Thus, while yearlong streamflow is contributed from the more elevated portions of the watershed, the usefulness of this supply is subject to serious silting due to run-off and erosion on the intermediate areas which not only destroys its value for direct use but which also constitutes a menace to the life of costly downstream improvements.

The absolute necessity for adequate water supplies in this Intermountain region clearly requires that the damaging floods which have become so common in recent years must be stopped. Abundant evidence suggests the most effective approach to this problem is through the control of rain and snow where they fall, but much more information is needed with respect to the specific influence of the many and varied factors which contribute to problems of water yield before effective watershed management practices can be developed. This information can be obtained only through a comprehensive program of research which will include: (1) the classification of watersheds according to their economic importance; (2) the determination of the run-off and erosion potentials of major soil and plant types; (3) the isolation and measurement of the specific influence of such factors as climate, soil, plant cover and slope on percolation, run-off and erosion; and (4) the development of methods of forest and range resource regeneration and utilization that will maintain watershed lands in the most favorable condition for yielding the maximum flow of usable water.

Research on these phases is an important part of the investigative program of the Intermountain Forest and Range Experiment Station. Forest and range studies aimed at the development of efficient reforestation and range revegetation practices and the determination of methods whereby the timber and forage resources can be used without adversely affecting the yields of usable water are being conducted at the Boise Basin and Arrowrock Branch Experiment Stations in Idaho, the results of which will have wide application on foothill range watersheds in the Snake River drainage. In Utah the principles and methods of preventing mud-rock flows and of maintaining desirable conditions for usable streamflow are being developed through studies at the Wasatch Branch Station on the Wasatch Front, while efforts at the Great Basin Branch Station on the Wasatch Plateau are pointed toward the development of range-watershed practices that will insure not only yields of water but also the use of summer range forage for grazing. Many observational studies have been made on the Colorado drainage but funds have not been available for carrying on as comprehensive a program of research as is needed on this important watershed.

PART II. SPECIAL DISCUSSIONS

C. THE INTERMOUNTAIN FORESTS

Mile upon mile of sagebrush interspersed only here and there by fields and pastures, strikingly lush and verdant against the parched desert background; flat or rolling plains bordered by foothills that hem the rugged peaks, simmering in the heat of the summer sun or sparkling in the glare of winter snows. Such is doubtless the dominant impression left on the mind of the tourist who travels the main highways of the Intermountain country. If he does not deviate from the beaten path, over the greater portion of the region, he is not likely to catch a glimpse of well-timbered areas; nor even of many tree species, save the neat rows of popular and locust around valley farm yards, the clumps of pinyon and juniper on dry slopes, and the firs and aspen in the cooler canyons and moister draws. But if he were to assume that this region is not blessed with timber resources he would be quite in error. For back in the hills and higher terrain, occupying strategic watershed areas, are roughly 25 million acres of forest land, some 12 million of which are in southern Idaho, over 5½ million in Nevada, nearly 5½ million in Utah and almost 2½ million in western Wyoming. Of this total forested area, almost 20 million acres are now in national forest ownership, classified by types as follows: about 1 million acres of alpine fir; about 2 million acres of aspen; nearly 3 million acres of Douglas fir; over 1 million acres of Engelmann spruce, almost 4 million acres of lodgepole pine; nearly 2 million acres of ponderosa pine; over 1½ million acres of white fir; and more than 4½ million acres of other species, including blue spruce, foxtail pine, juniper larch, limber pine, lowland white fir, mountain mahogany and pinyon pine.

1. The Importance of Forests to the Intermountain Region

The forested areas of the Intermountain states though comparatively meager in extent, low in volume and slow in growth of timber, represent one of their most precious heritages. Each timbered area serves not only as an important local source of lumber, posts, poles, fuel, etc., but also as a protective cover of watersheds, a source of forage, a home for game, and a haunt for the recreationist. This quintuple use augments the value of individual forest tracts manifold and justifies correspondingly larger expenditures for perpetuating their productivity than would be warranted in regions where only one or two major uses are being made.

a. Timber Resources

That forest management practices in Region 4 are dependent on multiple use of timbered areas is not, however, a valid assumption. The fact that consumption of domestic lumber far exceeds accessible local supply, that increasing mileage of roads and trails plus truck transportation are bringing previously inaccessible tracts closer to

the consumer, and that present and potential timber resources are at least from a local standpoint by no means insignificant make the probability of successful management of forest tracts for lumber, posts, poles, and other products high.

The estimated volume of commercial timber species on the national forest of Region 4 is as follows: saw timber (12 inches d.b.h. and over) - 47,792,933,000 board feet, young stand (4 - 12 inches d.b.h.) 16,852,719,000 board feet; cordwood (aspen, pinyon-juniper, and mountain mahogany) - 32,931,000 cords.

Considered from a sawlog standpoint, ponderosa pine now ranks first, followed by Douglas fir and lodgepole pine. However, practically every tree species in the region, if at all accessible, is of some commercial value, at least as fuel or even as structural material of temporary nature. Perfection of wood preserving methods and exhaustion of competing species are giving a new impetus to the use of many of the so-called "inferior" species, and their economic importance can be expected to increase as time goes on.

b. Timber Cut

Representative state-wide census figures indicate that the annual cut for all states wholly or partly in Region 4 (only Utah is entirely within the boundaries of this region) increased from 59,516,000 board feet in 1870, to 100,497,000 in 1899, to 1,009,500,000 in 1928. However, the bulk of the cut since about 1900 has been from northern Idaho which is not a part of Region 4.

c. Lumber Consumption

Considering the fact that all the states in the Intermountain region, except Idaho, must rely on sources other than their own for the major portion of their timber needs, per capita consumption is remarkably high. Census figures for 1928 provide a fair indication of volume consumption under relatively stable conditions, and these show that Idaho, Nevada, Utah, and Wyoming consumed a total of 527,351,000 board feet, only 33 percent of which was derived within the states (mostly Idaho). This represents an average annual per capita consumption of 416 board feet for the states wholly or partly in Region 4.

The significance of the timber business of the Intermountain region is not completely illustrated without a word about sawmills. There are today within Region 4 nearly 250 mills in operation. Notable is the fact the numbers of active mills have gradually increased since 1929 despite the onset of the business depression. In fact, self-help timber cooperatives operating sawmills have played a significant part in the administration of relief during the last few years. But even in normal times this enterprise has doubtless counted large in local economy.

d. Other Than Timber Values.

The major emphasis in the preceding paragraphs has been placed on the economic importance of regional timber resources. Timber production in the forests of the Intermountain country is, however, only one of 5 major uses, of which the value of any one of the other 4 may already, or at least in the future, greatly exceed that of the wood products alone. The other uses are, however, of more intangible character, hence of "incalculable worth", and their absolute value cannot be readily appraised in terms of volumes or of dollars and cents. Briefly, without regard to the order of importance, these are:

(1) Watershed protection. The forests comprise one of the primary guardians of nature's great reservoir - the soil. Their soil building and binding capacity is already fairly well recognized, and their protective value alone should justify every bit of the expenditures that are now being made to insure their perpetration.

(2) Grazing. Within the 25 million acres of forested land, associated browse and grass species constitute an important forage resource of the region.

(3) Game. Propagation of game is vitally related to forests and forest protection. Destruction of forests would introduce vast changes in the animal ecology of the region, and in many instances would mean extinction of game species. Increasing popularity of hunting is rapidly augmenting the importance of game as another manageable resource in the Intermountain country. The army of hunters on R-4 national forests increased from 37,567 in 1931 to 52,791 in 1936; annual kill of mule deer, for example, increased from 14,117 to 18,660 for the above years, respectively. Significant increases in annual kill were registered also for moose, mountain sheep and antelope. To insure against depletion of game supply calls for proper integrated use of related resources <u>especially forests</u>, but also forage and water.

(4) Recreation. In a region within which the majority of approximately one million inhabitants live in the non-forested and semidesert valleys, there is naturally a premium on timbered areas for recreational use. This type of use has increased tremendously in the last few years and bids fair to rank among the most important uses of the national forests. For example, during the past fiscal year, individual visits by special use permittees, hotel and resort guests, campers, and picnickers, numbered more than 3,280,000 for the national forests of Region 4.

2. <u>Management Problems of the Intermountain Forests</u>

The problems connected with the management of forest lands in this region are naturally similar in character to those in other regions, except that they are probably even more complex here for they do not hinge solely, nor in all cases importantly, on exploitation and utilization, but on all practices that affect the maintenance of the present

forest cover, or its establishment on areas where it has been destroyed. As such, these problems are not confined to ponderosa pine but include lodgepole, Douglas fir, aspen, Engelmann spruce and other types as well. More specifically, in the order of importance, they comprise:

a. Forest Protection

Today fire and insects constitute almost as great a menace to the successful execution of management plans as ever before in the past. Insect epidemics, especially in certain stands of lodgepole have passed beyond the stage of control by present methods. During the last decade over half a million acres of forest land have burned over in Region 4, necessitating an average annual expenditure of a quarter million dollars for suppression alone, to say nothing of losses. Damage is always far in excess of the stumpage value of the merchantable trees destroyed. Destruction of reproduction and other vegetative cover, accelerated snow melt, ash and debris-laden streams, loss of lives, recreational facilities and taxable property, and interference with industrial activities are only a few of the immediate effects of larger fires such as the Quartzburg and Elk Creek burns of Idaho. Both fire and insects constitute major problems in the administration of forests in this region.

b. Regeneration

In general the maintenance of a forest cover is dependent on successful methods of obtaining tree reproduction either through natural or artificial means. In the Intermountain country neither artificial nor natural methods have been consistently successful in the past due not only to drastic conditions of site and climate, but also to the fact that possibly the best methods still remain to be discovered. Natural regeneration problems hinge on methods of cutting, fire, slash disposal and other gross woods practices, and as such are most acute in the ponderosa and lodgepole pine types where the most extensive cutting is in operation at present. Artificial production problems are centered about nursery, planting and direct seeding technique. The importance of these is emphasized by the fact that every year from 10 to 60 percent of the timber stands burned over in this region are completely destroyed insofar as possibility of natural regeneration is concerned. This means that a significant portion of forest land suited primarily for timber growing is annually denuded by fire. It is unlikely that such areas will produce timber again within a reasonably short time if left to the slow process of natural succession. The only alternatives are planting and direct seeding, if the objective is the growing of timber instead of brush and weeds. In addition to the restocking of burned areas, artificial methods of forestation are also needed in the rehabilitation of overgrazed protection areas, on which destructive floods and mudflows are becoming a common occurrence. Revegetation of such areas will doubtless call for a number of different soil binding species, but the planting of tree species should be given priority on all sites where a reasonable degree of success can be assured without exhorbitant establishment costs.

c. Methods of Cutting.

These problems are most acute in ponderosa pine and lodgepole types where the largest commercial cutting operations are underway at present. In the former type the problem is largely one of employing methods which will reduce decadence of stands to a minimum, provide for seedbed conditions resulting in a satisfactory establishment of new tree growth, and a residual stand that will afford not only adequate site protection but also such conditions for snow storage as will result in maximum water yields. In the lodgepole pine type these same problems are equally acute. In fact, the difficulties are even greater because of the danger of insect attack, the invasion of alpine fir, and the necessity for more intensive seedbed preparation.

d. Timber Stand Improvement.

Artificial pruning is necessary at least in ponderosa pine if any clear timber is desired in rotations less than 150 years. Thinnings are also necessary in some young stands of ponderosa pine and Douglas fir, but more so in stagnating stands of lodgepole pine. Both thinnings and pruning are a desirable form of stand improvement in the types mentioned above, not only because they increase the value of the products, but also because they provide for profitable employment of the type of labor which has been abundant during recent years.

3. The Role of Research in the Management of Intermountain Forests

Progress in successful management of forest lands in this region is dependent on the rate at which the problems briefly and broadly outlined in the preceding section are satisfactorily solved. In many instances this calls for the most careful and detailed research, the prime objective of which is to discover methods of control through a knowledge of cause and effect.

Forest management research at the Intermountain Station is still in the formative stage, dating back only to 1931. Investigations to date have been concentrated mainly on problems of ponderosa pine. Naturally ultimate answers cannot be obtained in a number of cases in 5 or even 10 years; nevertheless significant results have been secured already (1) on both growth and yield of virgin, cut-over and second growth stands, (2) on thinning and pruning methods applicable to second growth stands, (3) on immediate effects of several cutting methods upon reproduction and reserve stands, (4) on immediate and delayed effects of fire on mature timber and reproduction, (5) on factors affecting establishment of reproduction, and subsequent survival and growth of both natural and planted seedlings, and (6) on snow storage in relation to timber cover. Adequate treatment of these phases of ponderosa pine management remains to be accomplished, but a good start has been made.

There is an urgent need at present to extend these studies into the lodgepole pine type in which regeneration, methods of cutting, slash disposal and insect control problems are particularly acute.

Eventually similar investigations should be extended to include the other important types, namely Douglas-fir, aspen, and Engelmann spruce.

The other problems not confined to any single type in the region are protection and artificial forestation. Reliable fire danger ratings must be worked out for different parts of the region in order to obtain the most effective expenditure of presuppression and suppression efforts. Restocking of burns and rehabilitation of other areas will demand the application of the best planting and seeding technique available. Studies on a small scale have been already initiated in these fields, but the big job lies ahead, and cannot be undertaken until additional funds and personnel are procured.

The station clearly recognizes that its prime responsibility is to secure reliable basic data which can be used in the formulation of the best integrated use plans for timbered areas. Its objectives are consequently larger than would be permitted by the dictates of sawlog production economics alone. For this reason in shaping its research program it is laying primary emphasis on regeneration methods to insure the perpetuation of a forest cover or its reestablishment on areas where it has been destroyed by fire or other agencies; and secondly on protection in order to insure a reasonable chance of survival once a forest cover has been established.

PART II. SPECIAL DISCUSSIONS

D. THE INTERMOUNTAIN LABORATORY

The nucleus of a well rounded-out research laboratory has been established at the Intermountain Station. Additions to the laboratory in the way of working space and new equipment during the past year have expanded the facilities for investigational work, making it possible to prosecute studies into many of the interrelationships of plant growth and soil conditions encountered in forest and range research. Hence, a more complete development of the research activities of the station is now possible.

1. Laboratory Investigations Essential to Research Program

Information that can be obtained only through laboratory investigations has been urgently needed for supplementing the field, research studies. It has been found essential to investigate the physical, chemical and biological characteristics of the soils upon which range management, artificial revegetation, erosion-streamflow and silvicultural experiments are being conducted. Knowledge of the chemical composition of plants grown under various conditions are necessary for proper range management and utilization. Germination characteristics of seeds of range and forest plants, and the effects of various environmental conditions on the growth of these plants are needing investigation, particularly in the silvicultural and artificial reseeding and revegetation studies.

Furthermore, owing to the character of the native plant flora, and the soil, climatic and topographic conditions peculiar to the western range and forest lands, certain problems encountered require for their complete solution the working out or development of the basic governing principles. Only the apparatus and equipment of a good laboratory can provide for the necessary precision and control for certain phases of this fundamental research.

2. A Beginning in Laboratory Research

Of necessity the development of this laboratory has been slow, but the nature of its growth has been entirely in accordance with the demands of the various research projects. For three years some soil and plant analyses have been conducted and a beginning in laboratory research has been made. With the recent additions, however, it is now in a position to serve the station in a rather broad manner and to a much greater extent than previously. Although the laboratory is not completely equipped for all kinds of research, a good nucleus has been formed, around which can be built, with reasonable additions of equipment and supplies from time to time, a well-balanced forest and range research laboratory.

3. The Laboratory Equipment

The research laboratory, as used in a broad sense, consists of three principal laboratory rooms, and in addition a balance room, a

store room for chemicals and glassware, a general workroom for grinding and preparing soil and plant materials for analysis, and storage space for soil samples and plant materials. These rooms are well situated with respect to light and ventilation, and they are generally pleasant rooms in which to conduct laboratory research. They are equipped with the usual laboratory work benches, tables, cupboards, sinks, chemical fume hood, and water, gas and electric outlets. Some of the more important pieces of equipment include, analytical and torsion balances, hydrogen-ion potentiometer, combination nitrogen digestion and distillation unit, combustion furnace, drying ovens, centrifuge, autoclave, seed germinator, electric ro-tap shaker and soil sieves, colloid mill, and electric and gas hot plates. The laboratory is also equipped with the usual glassware and chemical supplies.

4. Varied Types of Research Possible

With the equipment and apparatus available it is possible to conduct various types of laboratory investigations. Studies may be made of the moisture relationships and other physical characteristics of soils where range and forest plants are to be grown. Determinations can and are being made of soil texture by mechanical analysis, of soil moisture content, moisture-holding capacity and moisture equivalent. The color and structure of soils is also being studied in the laboratory to supplement the observations made in the field. The characteristics and quantity of the organic matter, the supply and availability of plant nutrients, the hydrogen-ion concentration and characteristics of the colloidal base exchange complex, as well as the numbers, kinds and activities of the micro-organisms of soils may be determined and studied. The seed germination characteristics, chemical composition and nutritive value of range plants may also be investigated.

5. Greenhouse Essential to Research Program.

Supplementary to the laboratories is a small greenhouse in which varied types of work are prosecuted. Studies are made of the growth habits and characteristics of various range forage species and forest plants; of the water relationships of range and forest soil types and their adeptability and nutrient needs for forage production; and other types of work which require controlled plant-growth environmental conditions. A few plants are also grown in the greenhouse during the winter and early spring months for later transplanting to small experimental plots on denuded range areas. Although the present greenhouse is admirably adapted to the needs of the station, it is rather small, and it is apparent that additional space will be needed in the near future.

6. Laboratory Personnel.

The research laboratory is being operated principally by temporary help under the supervision of the permanent members of the

staff. One ECW employee, who has had considerable experience in soils and field research, and three WPA assistants, each of whom have had college training in chemistry, had been given the responsibility of conducting the work. Occasionally other WPA labor is utilized in preparatory work and in conducting routine analyses.

7. Outlook for the Future

With the laboratory as now equipped it will not only be possible to conduct more work but to serve the projects in a broader way and to investigate the necessary and varied phases of the research which would not be possible of attack outside the laboratory.

PART III. RESEARCH CONTRIBUTIONS

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A. RANGE MANAGEMENT

Many underlying principles and practical methods of range management have been developed on the experimental ranges in the Intermountain region. The experiments for this work have been conducted primarily on summer range at the Great Basin Branch Experiment Station in Ephraim Canyon, on desert winter range at the Desert Range Branch Experiment Station in southwestern Utah, and on spring-fall range at the U. S. Sheep Experiment Station at Dubois, Idaho.

1. Summer Range

a. Factors of Range Management

(1) The basis for forage utilization and management of many important range forage plants was determined in a life history and forage value study reported by A. W. Sampson in U. S. Dept. Agr. Bull. 545, 1917. Prior to this work little was known of the growth habits and characteristics of many of the native western forage species.

(2) Plant succession and its use as a guide to range management was worked out by A. W. Sampson and published as a U. S. Dept. Agr. Bull. 791, 1919. This work established the fact that the character of the native vegetation can be used as a reliable indicator of the condition of the range and of the effect of long-time grazing treatment on the plant cover.

(3) A standard of range readiness as a factor in determining the proper periods of grazing, reported by A. W. Sampson and Harry E. Malmsten in U. S. Dept. Agr. Dept. Bull. 1405, 1926, showed the detrimental effect of continued early grazing and established a rough standard for determining the time at which a range may be stocked without injury to its forage plants.

(4) Carbohydrate production by Bromus carinatus is most rapid during active growth, but storage in roots and crowns is active only after plants start to dry. This explains why the season and frequency of clipping so greatly affect the carbohydrate metabolism of important summer range plants. The time of food storage by plants is a basis for preventing the injury caused by overgrazing, and its detrimental effect on the vitality and vigor of range plants. Range forage plants are living organisms and their requirements for growth must be considered in the rehabilitation and maintenance of range lands. These basic facts of plant behavior and physiological activity were established in a study directed by Edward C. McCarty and are to be published.

(5) The browse forage as summer range for cattle in southwestern Utah can be only partly utilized if grasses and weeds are to be maintained and livestock gains are reduced when most of the growth was utilized. In addition, suitable periods of grazing to allow for the

preservation of browse ranges were also scheduled. These data were reported in a study by C. L. Forsling and Earle V. Storm in U. S. Dept. Agr. Circ. 62, 1929.

(6) That uncontrolled heavy grazing may largely eliminate aspen reproduction was shown by A. W. Sampson in U. S. Dept. Agr. Bull. 741, 1919. This study also established principles for managing grazing in the aspen type so as to secure a better economic use of the lands, both in timber output and meat production.

(7) That the date of range readiness and later stages of plant development can be predicted 50 to 90 days in advance was established by studies at the Great Basin Branch Station. Such close correlations were found between the date of snow melting and subsequent plant development that regression lines gave far closer estimates than did the average date at which a given stage of plant development was reached. These studies are reported by D. F. Costello and Raymond Price in a proposed U. S. Dept. of Agr. Bull. entitled "Climate and Plant Development in Relation to Range Management,"

(8) Alternate moistening and drying increased the germination of seeds of certain western range plants but had little influence on others. This work reported by Sylvia M. Griswold in the Bot. Gaz. 98, 1936, also indicated the role of seed germination in plant succession and range management.

(9) Good forage grasses have been found unable either to establish themselves after reseeding or to produce a satisfactory forage yield on soils that are naturally raw, or from which the productive top soil had been removed by erosion. Preservation and maintenance of the top soil is therefore essential to good forage yields. Forage production and the suitability of different plants for a given range can be partly predicated by soil conditions. These and other results are soon to appear in a publication entitled "Procedure in Reseeding Range Lands of the Intermountain Region" by George Stewart, R. H. Walker and Raymond Price.

b. Forage Productivity Influenced by Erosion

(1) Soil erosion is a potent cause in the decrease of forage production. The value of plant cover in controlling, and the effects of overgrazing in causing soil erosion under range conditions have been studied in Ephraim Canyon, Utah since 1912. The removal by erosion of plant nutrients also greatly affects the type of vegetation that the soil can support. The early work in Ephraim Canyon also showed the use of terraces to be an aid in reseeding and planting. The above facts appear in the following publications:

(a) Range preservation and its relation to erosion control on western grazing lands. A. W. Sampson and Leon H. Weyl, U. S. Dept. Agr. Bull. 675, 1918.

(b) A study of the influence of herbaceous plant cover on sur-

face run-off and soil erosion in relation to grazing on the Wasatch Plateau in Utah. C. L. Forsling, U. S. Dept. Agr. Tech. Bull. 220, 1931.

(c) Surface run-off and erosion in relation to soil and plant cover on high grazing lands of central Utah. George Stewart and C. L. Forsling, Jour. Amer. Soc. Agron. 23:815-832, 1931.

c. Practicability of Artificial Reseeding Established

(1) Experiments conducted in the Intermountain region and particularly in Ephraim Canyon and on the Wasatch Plateau in central Utah have indicated that on the better soils and under favorable moisture conditions, it is practicable to revegetate depleted range lands by artificial reseeding. Mountain and common bromes, slender, crested and western wheatgrasses have been found suitable for reseeding the higher mountain range lands. Only in wet meadows have Kentucky bluegrass and timothy done well. The outstanding contributions in this work are as follows:

(a) The reseeding of depleted grazing lands to cultivated forage plants. A. W. Sampson, U. S. Dept. Agr. Bull. 4, 1913.

(b) Artificial reseeding on western mountain range lands. C. L. Forsling and Wm. A. Dayton, U. S. Dept. Agr. Circ. 178, 1931.

(c) Results of artificial reseeding trials on an oakbrush range. Raymond Price. (Submitted for publication.)

2. Winter Range

a. Preliminary studies in the Intermountain region have established the possibility of range recovery and rehabilitation when the range is properly stocked and managed. A well-organized program that can effect the rehabilitation of depleted range lands has been prepared, using as a basis the data and findings of a comprehensive survey of the spring-fall and winter ranges. These studies were conducted by George Stewart, G. D. Pickford, and Selar S. Hutchings and will be published in cooperation with the Utah State Agricultural Experiment Station.

b. Plant associations and forage conditions have been greatly disturbed by unrestricted grazing in the desert valleys of western Utah. Plant mortality, range depletion and invasion of inferior forage plants is correlated with the date and degree of use. Ring counts on the major desert shrubs revealed that the palatable shrub species such as white sage and black sage have failed to reproduce during the past 10 to 20 years whereas there has been a great influx of the inferior and unpalatable species since heavy grazing began. Two valleys were compared and the mortality and invasion were found to be most pronounced in the one more heavily grazed. George Stewart, Walter P. Cottam and Selar S. Hutchings report these studies in a forthcoming issue of the Jour. of Agr. Research.

c. Sweeping floristic changes in plant cover have occurred and plant succession has been upset at Mountain Meadows in southwestern Utah owing to settlement and grazing as shown by Walter P. Cottam and George Stewart in a proposed Journal article. A complete transformation has taken place since 1862 of a mountain meadow grassland into a sagebrush association devoid of all except small vestiges of the original meadow cover. Grazing reduced the plant cover and erosion by water cut deep arroyos through the deep alluvial deposits, lowering the water table and transforming the meadow into an arid sagebrush cover.

d. It has been shown that an almost wholesale occupation of depleted range areas by Russian-thistle and exotic annuals has occurred as a result of concentrated uncontrolled grazing. Many areas which from 1880 to 1905 supported luxuriant stands of white sage and grass now are almost completely occupied by this exotic annual. In Wah Wah Valley 487 pounds of usable black sage per acre has been replaced by 297 pounds of usable Russian-thistle.

e. Proper grazing management has caused a rapid recovery from the effects of heavy and excessive grazing on winter ranges. Many thousands of acres placed under management at the Desert Branch Experimental range in 1933 now produce 2.85 times as much forage as the adjacent outside range. Both areas were similar at the time of fencing. The most palatable plants make the greatest and most rapid recovery through increased plant vigor and seedling production and survival. George Stewart and Selar S. Hutchings. Being prepared for publication.

f. Palatability tables of all the major desert plants have been built up by the Range Management Division of the experiment station and are being used by the Soil Conservation Service, Indian Service, Division of Grazing, and Agricultural Adjustment Administration for making range surveys and determining carryingcapacity.

g. The Intermountain station led the way in focusing attention on the degree of depletion on public spring-fall and winter ranges, George Stewart, G. D. Pickford and Selar S. Hutchings doing the major share of this work.

h. The Intermountain station, largely with the aid of emergency funds, has fenced, constructed buildings, organized the Desert Range Branch Experiment Station, and started grazing and revegetation studies that have already begun to show how ranges must be handled to bring about rehabilitation, this work being headed by George Stewart and Selar S. Hutchings.

3. Spring-Fall Range

The following contribution have been made to the management of the sagebrush-wheatgrass ranges of the Snake River Plains in southern

Idaho by the experiments conducted at the U. S. Sheep Experiment Station near Dubois.

a. Owing to the annual fluctuations in rainfall, forage production was found to vary widely from normal; hence any basis of stocking to be uniform over a period of years and to provide for stability in range sheep management, must therefore be computed upon forage growth in subnormal years. Recommendations for proper stocking and other useful information is included in a manuscript by C. L. Forsling, G. W. Craddock, et al.

b. Although the native vegetation of spring-fall ranges is most seriously affected during the period of drought, the deleterious effects are prolonged into the second year or longer. This emphasizes the necessity for careful range management during the early spring following drought as well as during the actual drought period. Joseph F. Pechanec, G. D. Pickford, and George Stewart report on these phases in an article which will appear in Ecology.

c. The degree of deterioration in spring-fall ranges is closely related to the degree of spring utilization, whereas heavy fall grazing without spring grazing seems not to be detrimental to the range. Furthermore the rotation of use to avoid grazing the vegetation annually during the same stage of plant development has been found essential for range preservation on these ranges. These investigations have been under the supervision of Joseph F. Pechanec and G. D. Pickford.

d. The burning of sagebrush on spring-fall ranges with a good understory of grass increases the total production of palatable forage, provided the grass is protected from grazing for a year following burning. Promiscuous burning and continuous grazing, however, were found to result in serious damage to the perennial grass cover. Burning or heavy grazing in the fall will greatly impair sagebrush growth while causing minimum injury to cured grasses. These and other results of the burning experiments are reported by George Stewart, G. D. Pickford and J. F. Pechanec in an article which will appear in the Jour. Agr. Research.

4. Ranges in General

a. A review of the history of range use has been prepared, which explains much of the range management difficulty in western United States. In it is contained, in part, a story of failure to conserve forage supplies; to restore depleted ranges; to plan land use; to prepare for drought; and to avert the effects of depression. This history offers an explanation of the present condition of the range, and shows that range conservation and management are of primary importance in devising plans to bring about range restoration. The review is by George Stewart and appears in The Western Range, Senate Document, 199:119-133, 1936.

b. Jointly with the Northern Rocky Mountain and the California Stations the Intermountain Forest and Range Experiment Station has prepared a program of range management that will contribute strongly to

range rehabilitation for the West. This program has been built around the multiple-use principle and takes into account systems of grazing, range rehabilitation, proper season of range use, class of stock to be grazed and their proper distribution, the development of management plans, and the relationship of range use and management to watershed protection and erosion control. This program appears in a section entitled "The Management of Range Lands" and was prepared by L. F. Watts, George Stewart, M. W. Tablot, et al for The Western Range, Senate Document 199:501-522, 1936.

c. For handling the private range lands of western United States a program has been developed which might lead to stabilizing the livestock industry. Such a program involves (a) putting into operation effective range and livestock management, (b) recognition of the stewardship of land, (c) public ownership of many submarginal lands, (d) development of socially sound economic range units, (e) reduction of inflationary values in range land, (f) overcoming marketing handicaps, (g) improved credit facilities, (h) more equitable taxation, and (i) suggestions for research and extension education concerning the range resource. The program was prepared by George Stewart, W. G. Koogler and W. R. Chapline for The Western Range, Senate Document 199:483-499, 1936.

5. Development of Methods of Range Experimentation

The science of range management is of comparatively recent origin and in fact is still going through the beginning stages of its evolutionary development. There has been great need for improved methods of procedure and experimental technique in order that strictly objective information concerning the range might be obtained. Of necessity a part of the efforts of the Intermountain Forest and Range Experiment Station has been in this direction, and as a result a few distinct contributions of methodology have been developed. These have been principally in the methods of making range surveys and forage inventories and in the designing of experiments on a sound statistical basis. The important contributions in this connection are as follows:

a. The coordinate method, a scheme developed by G. D. Pickford and George Stewart for mapping low shrubs, has been published in Ecology 16:257-261, 1935.

b. An area list method of measuring range plant populations was developed by C. Kenneth Pearse and appears in Ecology 16:573-579, 1935.

c. The point-observation-plot (square-foot density) method of vegetation survey was developed by George Stewart and Selar S. Hutchings and has been published in the Jour. Amer. Soc. Agron. 28:714-722, 1936.

d. The weight estimate method of forage inventory is reported in a manuscript by J. F. Pechanec and G. D. Pickford.

These methods have been found superior to the chart quadrat, the large-estimate-plot, the stem-count, and other methods of forage estimate that have been proposed and used in times past. They will provide accurate and more reliable estimates of the forage inventory of a given area than other methods of range survey that have been commonly employed. They are easy to learn and to use, and owing to their time-saving qualities they greatly reduce the labor cost in making an accurate forage inventory of a given range area. Furthermore they serve better to meet the technical needs of the research investigator as well as the more practical needs of the range examiner.

In spring-fall range investigation grasses must be identified by their vegetative characters in early spring prior to flowering or at any time when flower stalks are not available. Keys which stress flower and seed characteristics are of limited service to range investigators during these periods. Hence, a key for the identification of grasses on the Upper Snake River Plains by their vegetative characters was developed by J. F. Pechanec. This new key is published in Ecology 17:479-490, 1936.

e. A correlation method for ecology as exemplified by studies of native desert vegetation was developed by George Stewart and Wesley Keller and appears in Ecology 17:500-514, 1936.

f. The need for statistical control in soils experiments is stressed by Rudger H. Walker in a paper to be published in the Jour. Amer. Soc. Agron.

These papers point out the necessity for the proper design of experiments that are to yield objective and independent information and they also show the direct application of statistical procedure to the interpretation of range research data.

g. A tentative recommendation of technique for grazing experiments on range pastures in arid or semiarid regions is outlined by George Stewart, Jour. Amer. Soc. Agron. 28:81-83, 1936. This is a distinct contribution in the development of a unified technique for the prosecution of grazing experiments on range lands. Specific recommendations have been made concerning the various details of range management in the handling of stock in grazing experiments.

PART III. RESEARCH CONTRIBUTIONS

B. FOREST AND RANGE INFLUENCES

A knowledge of the influence of plant cover on run-off and erosion has long been recognized as an essential element in the proper correlation and coordination of the uses of the timber and forage resources on the national forests of the Intermountain region. During the past 20 years many significant contributions have been made by research in this field on such aspects as (1) the value of streamflow from range-watershed lands, (2) determinations of the relation of plant cover to surface run-off and erosion, (3) the development of flood and erosion control methods, and (4) the perfection of special equipment and techniques for study purposes. The major contributions on these aspects are summarized below, with references to published material.

1. The Value of Streamflow from Range-Watersheds

a. Preservation of satisfactory watershed conditions on range lands is vital to the well-being of the West and therefore is of vital concern to the entire nation. Evidence has been presented to show that (1) 85 percent of the flow of important western streams comes from about 232 million acres of which 79 percent is range lands; (2) irrigation enterprises valued at about 6 billion dollars depend on streamflow from these water-yielding range lands; (3) silt resulting from accelerated soil erosion is being borne down into these streams from approximately 352 million acres, practically all of which is grazed; (4) floods are menacing the economic and social security of the entire region; and (5) the United States stands today at the cross roads and must choose between controlled management of its vast areas of unregulated grazing land or continued exploitation and eventual devastation. These aspects of the streamflow problem are discussed by Reed W. Bailey and Charles A. Connaughton on pages 303-339 of The Western Range, Senate Document no. 199, 1936.

b. In the Great Basin devastating floods which result from unwise use of steep range-watersheds produce far-reaching economic and social consequences. This is effectively illustrated by the situation in Davis County, Utah where during an 8-year period 1,833 acres of a 5,120-acre tract were flooded causing damage to residential, agricultural and industrial property of more than $1,000,000. Most of the flood run-off came from denuded isolated spots comprising about 846 acres of a 14,000-acre tributary watershed. Damage during the 8-year period was equivalent to $71.00 for each of the 14,099 acres of watershed land and equivalent to $1,182.00 for each of the 846 acres of denuded land from which most of the flood waters came. Decline in property values adjacent to or in the flood paths, inability to sell or use property as collaterial for loans, the fear complex produced by impending danger and the desire of residents to move to safer localities are effects remaining long after actual tangible

damages are forgotten and they can only be corrected by watershed management practices that will insure complete safety from devastating floods. Reed W. Bailey and A. R. Croft treated these phases in greater detail in a special report to the Forester in 1935 entitled "A Critical Study of a Steep Mountain Watershed in Terms of its Physiographic and Economic Aspects."

c. Streamflow from Great Basin range-watersheds when regulated by range-watershed management is of greater value than the combined surface assets of these areas. In Utah, which is a typical basin state, about $130 have been invested in agricultural, industrial, and social enterprises in the semidesert valleys for each of the 10,400,000 acres of mountainous lands above 7,000 feet elevation from which the necessary water supply is derived. At a minimum of $3.00 per acre-foot, the value of the water produced by each acre of watershed land for crop production alone is about $1.00 per year. Capitalized at 5 percent, the yearly return thus represents a value of $20 for each range-watershed acre above 7,000 feet elevation.

In Davis County, Utah a highly developed fruit and truck garden area, streamflow from 5,360 acres of range-watershed land is valued at about $210,000 representing $40 for each water-yielding acre, which is about 13 times the value of the land for grazing purposes. In this locality the lowest value of water yielded per acre of watershed is $13 and the highest is $104.

Because of these intricate and valuable watershed-community relationships one of the most desirable objectives of range-watershed management must be the preservation of regulated streamflow. These facts are brought out by A. R. Croft in a report "The Value of Streamflow from Great Basin Range-Watersheds", this article is to be submitted to the Journal of Forestry in 1937.

d. A survey of the Colorado River drainage above Lees Ferry, comprising about 98,000 square miles of the principal water-yielding area of the drainage indicates that 95 out of 115 principal tributaries are undergoing degradation which is of comparatively recent origin. The total value of present and proposed developments within and outside of the Colorado River basin, involving water yield from the area above Lees Ferry, is about $1,000,000,000. This huge sum represents investments for industrial, power, agricultural, and domestic purposes, in the streamflow of the Colorado River which is closely associated with the complicated geologic, physiographic, edaphic, climatic, and biotic factors that influence water yield and erosion on the watershed lands of this important watershed. Because of these complicated relationships dependent values can only be preserved in maximum usefulness by wise management of the watershed. A more detailed analysis of this situation is given in Milo H. Deming's report, "The Erosion Situation on the Watershed of the Upper Basin of the Colorado River" and in a special report "The Water, Erosion, and Range Problems in the Intermountain Region" by the Intermountain Forest and Range Experiment Station staff, 1936.

e. Water for the irrigation of 2-3/4 million acres in the Snake River drainage is derived from about 27 million acres of watershed which receive more than 20 inches of precipitation annually. For the Boise River watershed, one of the important tributaries of the Snake, the value of the annual water yield has been computed at more than 14 million dollars, or nearly $8.50 for each of the 1,700,000 water-yielding acres. 1/ This is many times the value of the combined annual forage and timber production.

1/ Lampert, J. M. Report of the Idaho State Planning Commission. May 1934.

2. The Relation of Plant Cover to Surface Run-off and Erosion

a. In the timbered areas of southern Idaho, virgin and properly cut-over forests delay the melting of snow from 11 to 17 days longer than do clear-cut or burned-over areas and hence are superior for water-yielding purposes. These are some of the conclusions in C. A. Connaughton's article, "The Accumulation and Rate of Melting of Snow as Influenced by Vegetation", Jour. of Forestry, 33:564-69, 1935.

b. Erosion is directly related to intensity of burn and steepness of slope in the ponderosa pine forests of the Snake River drainage. This, as pointed out by C. A. Connaughton in an article, "Forest Fires and Accelerated Erosion", Jour. of Forestry 33:751-752, 1935, makes erosion control an important factor in the fire problems of watershed areas.

c. A survey of nearly 400,000 acres of typical range lands on the Boise River watershed in 1930 showed 62 percent of the area to be eroding at an accelerated rate. The cumulative effect of past grazing as expressed by accessibility of range to livestock is the most important of the seven factors studied in bringing about the accelerated erosion. Plant type, soil characteristics, aspect, plant density, rodent infestation, and gradient are important in the order named. Grazing, however, "stands out as by far the most important; (1) because it is important in itself; (2) because it accentuates the influence of nearly all the other factors; and (3) because it is the one factor most susceptible of control." Thus, in 1936 wrote F. G. Renner in U. S. Dept. Agr. Tech. Bull. 528, bearing the title "Conditions Influencing Erosion on the Boise River Watershed."

d. Extensive excavations and examinations of the root systems of 50 common range plant species on the Boise River watershed indicated that the most desirable forage plants which have been largely replaced by annual weeds as a result of severe grazing, all have extensive fibrous root systems which are highly effective in holding the soil in place and in promoting the absorption of water by the soil. L. E. Spence conducted this work and in an article submitted to the Jour. of Forestry for publication in 1937, reports his findings under the title "Root Studies of Important Range Plants of the Boise River Watershed."

e. The relative effect on run-off and erosion of four common range types under different range conditions on the Boise River watershed as determined by the application of artificial precipitation with special portable equipment was found to be as follows:

Range Type	Percent of applied rainfall which ran off	Tons of material eroded per acre
Bunchgrass	Trace	Trace
Cheatgrass	25.5	1.05
Lupine-needlegrass	49.9	2.38
Annual weed	60.8	7.64

Steepness of slope, artificial rainfall intensity and conditions of the surface soil were all carefully controlled in this study. It is highly significant from a watershed protection standpoint that the bunchgrass type, the virgin range of the region, yielded no measurable amount of run-off or erosion under any condition of the experiment. Slopes as steep as 40 percent were adequately protected from erosion by the bunchgrass type when subjected to storms of 1.80 inches in 30 minutes, whereas comparable slopes vegetated by inferior forage plants were seriously gullied by storms of this intensity. These facts were brought out by Geo. W. Craddock and C. Kenneth Pearse in a report "Surface Run-off and Erosion on the Granitic Mountain Soils of Idaho as Influenced by Range Cover Soil Distrubance, Slope, and Precipitation Intensity" which is to appear in 1937 as a U. S. Dept. Agr. Circ.

f. The presence of an herbaceous plant cover was found to induce a 71 percent increase in the rate of absorption of surface water by the granitic soils of southern Idaho and fibrous-rooted species were found to be $2\frac{1}{2}$ times as effective as taprooted species in inducing absorption, according to studies made in 1935 on 1-square foot plots by C. Kenneth Pearse and Samuel B. Woolley. These studies are reported in the Jour. of Forestry, 34:884-887, 1936 under the title "The Influence of Range Plant Cover on the Rate of Absorption of Surface Water by Soils."

g. Herbaceous plant cover may provide effective control of summer run-off and of erosion on range-watersheds. During a 15-year period when the plant cover on watershed B was held at 40 percent density while that on watershed A was changed from 16 to 40 percent, the A/B ratio of silt eroded, as a result of torrential rains, changed from 5.42 to 2.48. This is shown in table 1. Silt eroded as a result of run-off from melted snow water from A decreased 54 percent during the same period.

Table 1. - Periodic annual percent of run-off and amount of eroded material per acre from watersheds A and B, 1915-1929 inclusive, Great Basin Branch Experiment Station, Utah, showing changes in the A/B plant cover, run-off and erosion ratios.

Periods	Area A			Area B			A/B Ratio		
	Plant density	Run-off	Eroded material	Plant density	Run-off	Eroded material	Plant density	Run-off	Eroded material
	%	%	Cu.ft.	%	%	cu.ft.			
1 Annual Average 1915 - 1920	16	10.33	133.82	40	2.52	24.67	0.4	4.10	5.42
2 Annual Average 1921 - 1923	16 to 40	8.74	105.03	40	3.03	37.30	0.7 1/	2.88	2.82
3 Annual Average 1924 - 1929	40	5.49	19.15	40	5.23	7.73	1.0	1.05	2.48

1/ Average for period

The A/B percent run-off ratios as a result of torrential rains changed during the same period from 4.10 to 1.05 but the run-off from melted snow remained approximately constant. These are the more outstanding results reported by C. L. Forsling in U. S. Dept. of Agr. Tech. Bull. 220, 1931, entitled "A Study of the Influences of Herbaceous Plant Cover on Surface Run-off and Soil Erosion in Relation to Grazing on the Wasatch Plateau in Utah."

h. A flood and erosion survey of the 25 important watersheds in Utah that have flooded in recent years shows that the depleted condition of plant cover is considered to have played a material part in 22 cases and in 15 of the 22 cases depletion of plant cover is considered to be the major factor giving rise to conditions favorable for flood run-off. In 7 cases natural physiographic conditions unfavorable to plant growth were materially responsible for light plant cover and in only 3 cases are natural physiographic features considered the principal cause of flood run-off during torrential rainstorms.

In 16 out of 22 cases where floods are attributable, in whole or in part, to plant cover depletion, the land from which the floods came is largely under private control, either owned or leased, or is partially open public domain. In 9 cases the watersheds included national forest land which contributed to the floods.

It is readily apparent, therefore, that the restoration of adequate plant cover on range-watersheds will do much to abate floods in Utah and that this may be done more effectively through public ownership of critical watershed areas. This is the conclusion reached by C. L. Forsling, R. J. Becraft, Milo H. Deming and Reed W. Bailey in an unpublished report entitled "Utah Flood-Erosion Survey."

i. The destruction and modification of the plant cover by overgrazing is the one known cause capable of reversing the gradational processes that have recently occurred throughout the Colorado Plateau province. The formation and maintenance of soil on slopes and of alluvium in the valleys, in a topographically young region having a variable climate are accomplished by a delicate adjustment between the factors that control gradation. When the plant cover - one of the controlling factors - was materially reduced and modified, this adjustment was disturbed, resulting in more intensive run-off from the slopes and down the valleys, which caused a reversal in the gradational process.

Lack of change in gradation of naturally barren areas, absence of evidence pointing to diastrophism, and the sequence of settlement and recent valley channeling provide additional evidence to support the conclusion that destruction and modification of the plant cover are major causes of the present cycle of channel cutting and are discussed by Reed W. Bailey in an article entitled "Epicycles of Erosion in the Valleys of the Colorado Plateau Province" which appeared in the Jour. of Geology 43:337-355, 1935.

j. In depth of cutting, quantity of material, and in size of boulders carried, recent floods from the short steep drainages of the

Wasatch Front in northern Utah, exceed any others that have taken place in this locality since the recession of Lake Bonneville, approximately 20,000 years ago. Working on the promise that the past history of gradation (cutting and deposition) of streams and drainages is recorded in the deposits in the stream valleys, deltas, or alluvial fans, comparisons were made of the extent of recent cutting, and the nature and quantity of deposits which had occurred in the past. These observations revealed that recent cutting and deposition has been entirely out of proportion with normal stream action during the post-Bonneville epoch. Almost without exception these deep channels were found to lead back to comparatively small areas, on otherwise well-vegetated watersheds, that had been denuded of plant and litter cover by destructive grazing and fire. This evidence has been described by Reed W. Bailey, C. L. Forsling and R. J. Becraft in U. S. Dept. Agr. Misc. Publication 196, 1934 under the title "Floods and Accelerated Erosion in Northern Utah."

3. Improved Influence Study Methods

a. Two units of portable apparatus have been developed by the station in recent years which have greatly facilitated the gathering of information on run-off and erosion and on the absorption of surface water by soils. One of these units is an artificial rainmaking device which makes it possible, in the field, to measure run-off and erosion under controlled conditions of plant cover, slope, soil condition and precipitation intensity. The construction and operation of this equipment has been described in detail by C. Kenneth Pearse in a mineographed progress report prepared in 1936 entitled "Specifications for the Construction and Operation of a Portable Apparatus for Measuring Surficial Run-off and Erosion."

The second unit is a device for measuring in place the rate of absorption of surface water by soils. This unit is especially well adapted for determining the influence of such factors as the presence or absence of plant cover and the texture, wetness, and organic content of soils on absorption. This unit has been described by C. Kenneth Pearse and F. Dwight Bertelson in an illustrated mimeographed report prepared in 1937 entitled "The Construction and Operation of the Apparatus for the Measurement of Absorption of Surface Water by Soils."

b. Because every stream or drainage records its gradational history (cutting and deposition) in the deposits made in stream valleys, deltas, or alluvial fans, a comparatively reliable method is available by which the recent behavior of any stream may be compared with that during the immediate geologic past. This method has been applied effectively in analyzing flood problems in the Colorado Plateau province and in the Wasatch Mountain region. The method of approach to the study of any flood problem by this station now includes the determination of past history of flow insofar as this is revealed in the deposits made by the stream.

With a more adequate understanding of the past history of streamflow, which is often obtained by such studies, the possibility of applying effective corrective measures can be determined.

4. Upstream Engineering

a. The contour-trench system of flood and erosion control as developed and applied on the Davis County watershed in Utah is a practical and effective method of preventing torrential run-off and soil losses and of rehabilitating seriously eroded areas on range-watersheds. This system consists of a series of zero-grade trenches spaced close enough together to hold 75 percent run-off from a 2-inch rainstorm, and with about 200 compartments or reservoirs per mile of trench. The system prevents soil losses and holds the water on the ground where it falls; this prevents torrential run-off and erosion, increases available soil moisture and stabilizes soil for plant growth. Torrential rainstorms during the summer of 1936 on trenched watersheds in Davis County, Utah did not cause floods, whereas rainstorms of approximately equal intensity and volume on adjacent untrenched watersheds produced violent mud-rock flows. Reed W. Bailey and A. R. Croft describe this system and its application in an ECW Forestry publication entitled "Contour-Trenches Control Floods and Erosion on Range Watersheds", which is to be printed in 1937.

PART III. RESEARCH CONTRIBUTIONS

C. FOREST MANAGEMENT

Since the inception of silvicultural investigations at the Intermountain station in 1931, studies have been aimed primarily toward the perfection of methods of cutting and other management practices in the ponderosa pine type of central Idaho. Significant results have already been published on the following phases:

1. Growth

Measurements of growth on permanent sample plots established in 1913 showed that virgin stands in this locality have been yielding a net increment of 139 board feet per acre per year, indicating that for these conditions, barring fire and insect epidemic, growth is by no means at a standstill but rather exceeds that of most cut-over stands. Variations of growth and mortality in terms of diameter and total and merchantable volume and in relation to species, tree class, aspect and other factors are reported by C. A. Connaughton in the Jour. of Forestry 33:73-79, 1933. Similar data for selectively cut stands, indicating average net annual growth rates of 136 and 155 board feet for about the same period of time for plots on the Payette and Salmon Forests, were reported in 1935 by E. L. Mowat in mimeographed progress reports entitled "Methods of Cutting Ponderosa Pine."

2. Yield

Growth prediction and planning of stand improvement practices in young stands and cut-over lands will be greatly aided by the publication of yield tables for even-aged ponderosa pine, an inter-regional study of which the station contributed sample plot measurements for Region 4. The manuscript on the "Yield of Even-aged Ponderosa Pine Stands" was prepared by Walter H. Meyer of the Pacific Northwest Station and will soon appear as a U. S. Dept. of Agr. Tech. Bull.

3. Stand Improvement

Demonstrations of conventional and "crop tree" thinning methods in young pine stands were developed on the Boise Basin Experimental Forest, and aid in 1935 was given in the preparation of a mimeographed handbook entitled "Handbook for Timber Stand Improvement and Clean-up of Roadside Strips" to be used as a guide in similar timber stand improvement work by the CCC and others in this region.

4. Economic Selective Logging

The recent emphasis upon economic selective logging on both private and public lands created a demand for information on this practice. To meet this demand H. S. Hinkley, et al prepared a report in 1935 en-

titled "The Limit of Profitable Utilization in Southern Idaho Ponderosa Pine" assembling all pertinent data for this and other regions in coordinated and simplified form, with a detailed example of the determination of the limit of profitable utilization for a central Idaho pine operation.

5. Forestation

The opportunity for an expanded forest planting program by relief labor brought to the fore problems of selection of sites, species and planting stock that have been partially solved by intensive studies of experimental plantations. A preliminary manuscript report by W. B. Read, E. L. Mowat, and C. A. Connaughton was prepared in 1935 and has been issued to those directly concerned.

6. Fire Damage

A comprehensive picture of damage to the forest caused by the catastrophic Boise Basin fire of 1931 was given in brief form by C. A. Connaughton in the Jour. of Forestry 34:46-51, 1936. Based on a detailed survey of 9,308 acres and the continued record of sample plots, this study serves as a basis for damage appraisals and management plans for similar burns. Accelerated erosion following the fire was noted on 42 percent of the cut-over area and 28 percent of the uncut area. Definite relations of erosion to degree of slope and intensity of fire are discussed by C. A. Connaughton in another Jour. of Forestry article 33:751-52, 1935.

7. Snow Storage

A study of snow accumulation and melting under various forms of forest cover, as reported by C. A. Connaughton in the Jour. of Forestry 33:564-69, 1935 and in the Bulletin of the American Meteorological Society 17:48-49, 1936, demonstrated that a young stand with many small openings in the forest canopy intercepts only about one-half as much snow as a mature virgin stand and delays spring melting almost as long, thus providing more favorable conditions for water yield.

PART IV. CURRENT ACCOMPLISHMENTS

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A. RANGE INVESTIGATIONS

1. Summer Range - Wasatch Plateau

Effort on summer range studies at the Great Basin Branch during the past two years has been directed primarily toward finishing old experiments and getting them into manuscripts, preparatory to reorganizing the investigational work. This "cleaning up" will probably be completed during 1937. During 1936 the work included (1) the preparation and submission for publication of five manuscripts on important phases of range management, (2) analysis of the data from the plant nutrition clipping, browse clipping, and grass clipping studies and from quadrat and sample plot transects, and (3) routine field work on plant vigor, natural revegetation and climate and plant growth studies.

a. Early Seasonal Use Gives Best Forage Yield and Permits Normal Food Storage

When growth is removed only once during the grazing season, the early season clipping of mountain brome (Bromus carinatus), a highly palatable forage grass, results in maximum forage yields and permits normal carbohydrate storage as determined by combined yield and nutritional studies at the Great Basin Branch Station. Past studies have shown that repeated cropping of young growth in mountain brome is detrimental to the plant. The present study substantiates this fact but in addition shows that if this plant is clipped early and allowed to grow during the remainder of the season without further croppings, maximum yield is produced and a normal quantity of carbohydrate is stored and apparently there is no injury to the plant. This fact is shown by results presented in table 2.

b. Continual Frequent Clipping Reduces Food Storage

The yield and amount of carbohydrate stored in mountain brome (Bromus carinatus) are highest when the plants are clipped early and only once at 4 inches above ground and lowest when clipped either once at the time seeds are ripe or three times during the middle active growing period (see table 2). When plants are clipped once early in the season sufficient growing weather remains to permit the plants to complete their normal life cycle. On the other hand, when clipping is delayed in the season or concentrated during the most active growing period, the normal growing cycle of the plant is upset and the remaining season is too short to permit recovery and completion of normal growth.

Clipping at 4 inches from soil line at 15-day intervals throughout the season leaves sufficient herbage to manufacture large amounts of carbohydrate but forage yields are low as a result of the frequent croppings. Thus, it appears that less frequent croppings

Table 2. Forage yield and carbohydrate storage by mountain brome (*Bromus carinatus*) when clipped at different heights and frequencies.

Frequency, height and time of clipping	Forage yield	Carbohydrate storage
Clipped once		
plants 4 inches high	High	Near maximum
heads high in boot	Medium	High
seed in milk	Low	Low
seed ripe	Very low	Very low
Clipped 3 times at 15-day intervals		
early in season	High	High
middle of season	Very low	Very low
end of season	Very low	Low
Clipped throughout season at 15-day intervals		
plants 1 inch high	Low to nil	Very low
plants 4 inches high	Low	High

at 4 inches would also result in normal yields of forage as well as high-stored reserves in the plant roots and crowns.

c. Full Utilization of Range Forage Grasses Reduces Forage Yield

Utilization of forage grasses of western mountain range lands to within 1 inch of the soil line causes serious losses in forage yield and decreases the plant cover. This has been shown by experimental clipping studies at the Great Basin Branch Station in central Utah.

Range managers on national forests have sponsored and practiced moderate use of range forage for many years to maintain yields on a sustained basis. Notwithstanding this demonstration, thousands of acres of other public ranges have been allowed to deteriorate from too close use. Table 3 shows the detrimental effects of clipping 1 inch above soil line on yield and basal area of two major forage grasses.

Table 3. - Forage yield and basal area of two major forage grasses clipped 1 inch above soil line annually for 6 years.

Species	One year preceding clipping: Yield dry wt.	First year of clipping: Yield dry wt.	First year of clipping: Basal area	End of sixth & final year of clipping: Yield dry wt.	End of sixth & final year of clipping: Basal area	Year following final clipping: Yield dry wt.	Year following final clipping: Basal area
	Grams	grams	cm 2	grams	c.m.2	grams	cm. 2
Slender wheatgrass (Agropyron pauciflorum)	311	120	4,346	118	1,476	86	2,795
Mountain brome (Bromus carinatus)	429	123	2,304	130	943	115	834

Recognition by users of the public range of the damaging effects of too heavy utilization of range forage plants, especially during drought years will do much toward the rehabilitation of this vast resource.

d. Current Growth of Valuable Browse Plant can be Closely Utilized in the Fall without Causing Injury

The current growth of birchleaf mahogany (Cercocarpus montanus), an important western browse plant which furnishes much of the forage during fall grazing on certain range lands within the Intermountain

region, can be utilized in the fall until only 1 inch of new twig growth is left without injury to the plant. Data from this study on clipping, conducted at the Great Basin Branch Station, are presented in table 4, which shows the average dry weight of clipped material, average length of current twig growth, and general condition of birchleaf mahogany under three degrees of clipping.

Table 4. - Average weight and length of current twig growth of birchleaf mahogany under three methods of clipping.

Method of clipping	Current twig growth: dry wt.	Current twig growth: length	Appearance of plant
	grams	cm.	
All current growth removed	306	1.69	Hedged; many dead stems; growth open, short, basal and coarse
1-inch current growth left	113	2.02	Well foliated, growth fairly open and occurs rather uniformly on entire bush
$2\frac{1}{2}$ inches current growth left	43	2.39	Well foliated, growth somewhat compact
Unclipped	-	2.01	Well foliated, growth somewhat compact

2. Spring-Fall Range

a. Forage Production Influenced by Climate

According to studies being conducted on spring-fall range at Dubois, Idaho forage production was found to vary from 60 percent below normal in years of deficient precipitation to 40 percent above normal in years of above normal precipitation. Furthermore, two or more years of deficient rainfall often occur in sequence. Any basis of stocking to be uniform over a period of years and to provide for stability in range sheep management, must therefore, be computed upon forage growth in subnormal years rather than on years with normal or above normal forage production. Such a basis allows some forage to be wasted in optimum years but protects both the range and the livestock during drought periods, although in extremely poor years it may necessitate nearly complete utilization of the available forage.

The results of several years study show that this utilization should be based on 60 to 75 percent of the normal forage production on ranges with conditions compared to those of Dubois, Idaho.

b. Effects of Drought on Native Vegetation

Although the immediate effect of drought on the native vegetation of spring-fall ranges is the most serious, injurious effects on plant cover are prolonged over an extended period. During the 1934 drought immediate decrease in forage production was 62 percent for grasses on the sagebrush-wheatgrass ranges of the upper Snake River plains in Idaho. Although better growing conditions prevailed, the following year forage production was still 52 percent below what it had been prior to the drought. These findings emphasize the need for careful range management during the early spring following the drought year as well as during the actual drought period. Stocking on spring ranges should be greatly reduced during an unusually severe drought and for a year after, and rotation of the range-use-period should also be provided.

c. Rotational Grazing Found Desirable

Experiments conducted at the U. S. Sheep Experiment Station near Dubois, Idaho show that rotation-grazing use to avoid removing the vegetation annually during the same stage of plant development is essential to spring-fall range preservation in southern Idaho. Fairly heavy grazing year after year during a fixed period proved detrimental to the range. One pasture grazed at the same time each spring showed some deterioration, although it was subjected to only light grazing (11.9 sheep-days per acre). On the other hand, outside the pasture the open range, which is stocked at the rate of approximately 10.5 sheep-days an acre during the spring season, but upon which the grazing is rotated in such a manner that the same area is not always grazed during the same period of the growing season, has noticeably improved in condition.

d. Heavy Spring Grazing is Detrimental to the Range

Investigations have shown also that where a pasture has had no spring use but has been heavily grazed in the fall (i.e. with 60 to 85 percent of all feed removed), there has been no measurable deterioration except as a result of climatic fluctuations. On the other hand, pastures grazed heavily throughout the spring season (65 to 88 percent removal) have declined approximately 69 percent in forage production. Moderate spring grazing (50 to 55 percent removal) resulted in only slight range deterioration. The degree of deterioration in spring-fall range is thus seen to be closely related to the degree of spring utilization, with heaviest use resulting in greatest deterioration.

e. Fall Grazing Less Injurious than Spring Grazing

At the U. S. Sheep Experiment Station one pasture, which is grazed only in the fall, yielded 4,100 sheep-days of feed yearly during the period 1923-1935, and in 1936 still produced 12 tons of forage on the 80-acre area. Another pasture, which was similar in all respects at the beginning of the grazing trials, but which is grazed early and continuously during the spring season and again in the fall, produced only 2,800 sheep-days of feed yearly during the same period, and in 1936 produced only 2.5 tons of forage. Furthermore, sagebrush has increased to such an extent under spring grazing that only one-half ton of forage is available to livestock in comparison with 10 tons of available forage in the fall grazed pasture.

f. Carrying Capacity Increased by Burning Heavy Sagebrush

On spring-fall ranges 15 miles north of St. Anthony, Idaho, which have a good understory of grass associated with a relatively heavy growth of sagebrush (Artemisia tridentata), burning of the sagebrush greatly increased the total production of palatable forage as well as the availability of the forage, provided no grazing use was made of the area for a year following the burn. The increases in total available herbage following burning have been 34 percent for the light burn, 69 percent for the medium, and 28 percent for the heavy. The increase in forage production resulted largely from the increased growth of Agropyron dasystachyum, which either doubled or tripled after removal of the sagebrush. Poa spp. and Festuca idahoensis were affected adversely by burning whereas Stipa spp. increased approximately 60 and 90 percent in the light and medium burns respectively but decreased in the heavy burn.

On the basis of a feed requirement of 12 pounds of palatable forage a day for each ewe with suckling lamb, a section of managed unburned range would support 1,000 ewes for 7 days. As a result of burning, the carrying capacity, based on average production of combined burn classes, was increased to 18 days per section.

g. Heavy Grazing and Promiscuous Burning Detrimental to Perennial Grasses

Continued heavy grazing and promiscuous burning on spring-fall ranges in Utah have resulted in serious damage to the perennial grass cover. Areas subjected to this type of treatment have lost 85 percent of their perennial grass cover. Heavy grazing without burning resulted in a decrease in perennial grasses and an increase in sagebrush, whereas promiscuous burning without grazing depleted the perennial grass stand and also destroyed the sagebrush. In all cases, overgrazing and promiscuous burning encouraged the growth of annual grasses and weeds of low forage value at the expense of the better forage plants, and resulted in a lowered grazing capacity.

h. Sagebrush Injured by Fall Burning or Heavy Grazing

Burning or heavy grazing in the fall may greatly impair sagebrush growth though causing minimum injury to cured grasses. An

explanation of this is shown in the fact that more than 50 percent of the food reserves (starches and sugars) of the fine-leaved sagebrush, (Artemisia tripartita), are stored in the current stem and leaf growth and 20 percent or more in the main stems and secondary branches, whereas virtually 100 percent of the starch and sugar storage in the bunchgrasses is in the roots and root crowns.

i. Boise range - granitic soils

The system of 100 quadrats and 105 major plots has been supplemented by the establishment of four gridiron surveys on protected areas ranging from 1 to 100 acres each and on an equal number of comparable grazed areas. On each of these enough measured samples of the vegetation were taken to insure a statistically sound description of the density and composition of the area. The area-list method was used to measure the random gridiron plots. This extensive system of surveys should prove a valuable addition to the more intensive plots and quadrats in studying natural revegetation of the watershed.

3. Desert Shrub Ranges

a. Heavily Grazed Winter Ranges are Invaded by Russian-thistle (Salsola pestifer)

Russian-thistle has almost completely overrun all parts of winter ranges in the Intermountain region where the native plant cover has been broken. Many of the better forage plants have suffered high mortalities and the remaining live plants of these species show heavy loss in vigor. By this means, the production of native perennial forages has been greatly reduced below the potential capacity of the range. Two areas in western Millard County, Utah were studied in detail in 1936, one in the black sage (Artemisia nova) association 12 miles west of Milford, Utah and the other in the white sage (Eurotia lanata) association in Wah Wah Valley 25 miles west of Milford, Utah.

b. On Black Sage Ranges - Milford Bench.

Black sage (Artemisia nova) is one of the most valuable forages and the association occupies extensive areas throughout the winter ranges of Utah, Nevada, and southwestern Wyoming. From the beginning of winter grazing on the deserts of the West, black sage has been highly prized as sheep feed. Because sheep relish its nutritious forage, the black sage associations have been excessively grazed and have suffered heavily in plant mortality and plant vigor. These areas depleted of native plant cover have become occupied by Russian-thistle to the practical exclusion of all other species, especially during seasons of favorable moisture such as 1936.

Data from Milford Bench, 12 miles west of Milford, Utah shown in table 5, are typical of most of the extensive areas of black sage. This replacement of 487 pounds of usable black sage per acre by 1,190

pounds of Russian-thistle of which 297 pounds is usable tends strongly to unbalance the range feed supply and is therefore a menace to the range livestock industry. On this heavily grazed range Russian-thistle now makes up 86 percent of the total plant cover, although it rarely occurs on properly utilized range where the native plants are vigorous.

Plant counts on the open heavily grazed range (table 5) show that 38 percent of the black sage plants and more than half of the ricegrass and white sage plants are dead in contrast to an average mortality of 5.3 percent on similar but properly grazed ranges.

The mortality of black sage varies from one locality to another; in the south end of Pine Valley 97 percent is dead, in central Nevada 47 percent, and in Hamblin Valley where winter grazing is reduced by heavy snowfall, about 17 percent is dead. In addition to the heavy mortality of these valuable forages, the remaining plants have been reduced in vigor and now produce only meager amounts of forage.

Plant vigor, determinations, based on the amount of forage produced by 1,000 plants, show that plants on the open range produce only one-third to one-sixth as many pounds as those on the properly used ranges. Black sage produces 28 pounds of forage on the open range as compared to 78 pounds under proper use, a reduction of two-thirds. White sage has been reduced almost three-fourths, and ricegrass five-sixths.

Fifty-three percent of the ricegrass and 64 percent of the white sage in Wah Wah Valley are dead, old roots and stumps witnessing their former abundance. The destruction of these plants has made possible the invasion of Russian-thistle and rabbitbrush. Moreover, the surviving plants of ricegrass and white sage have also been reduced in vigor. One thousand plants of white sage on a managed range produced 27 pounds of forage as compared to only $4\frac{1}{5}$ pounds on a comparable open range, indicating a reduction of approximately 83 percent in vigor. Ricegrass shows a vigor loss of 97 percent, 1,000 plants produce 51 pounds of forage on the properly grazed ranges and only $1\frac{1}{2}$ pounds on this open range.

c. Variability of Forage Conditions in Region

Mortality of white sage on open range varies considerably in different localities. In Red Desert, Wyoming it was found to be 31 percent; in Pine Valley, Utah 22 percent; in Milford Valley, Utah 84 percent; in the south end of Pine Valley, Nevada 35 percent; and in Tule Valley 24 percent, whereas on properly utilized range the mortality of this same species was found to be only 2 to 7 percent.

The heavy mortality of the palatable shrubs and their replacement by Russian-thistle is typical of vast areas of winter range in

Table 5. - Yield of forage and condition of forage plants on Milford Bench, Utah.

Species	Palatability	Field-cured weight of total plant growth per acre: Managed range	Field-cured weight of total plant growth per acre: Typical open range	Field-cured wt. of usable forage per acre: Managed range	Field-cured wt. of usable forage per acre: Typical open range
		pounds	pounds	pounds	pounds
Curlygrass (Hilaria)	.65	15.19	13.51	9.87	8.82
Ricegrass (Oryzopsis hymenoides)	.85	7.57	2.34	6.43	1.99
Russian-thistle	.25	.48	1,190.02	.12	297.50
Other weeds	.55	13.80	--	7.59	--
Black sage (Artemisia nova)	.80	760.59	151.82	608.47	121.46
White sage (Eurotia lanata)	.65	15.56	.69	10.11	.45
Rabbitbrush (Chrysothamnus steno.)	.25	3.74	20.55	.94	5.14
Totals		816.93	1,378.93	643.53	435.36

Species	Dead Plants: Managed range	Dead Plants: Typical open range	Plant vigor based on forage produced per 1,000 plants: Managed range	Plant vigor based on forage produced per 1,000 plants: Typical open range
	Percent	Percent	Pounds	Pounds
Ricegrass (Oryzopsis hymenoides)	5	57	33.04	4.49
Black sage (Artemisia nova)	6	38	77.60	28.35
White sage (Eurotia lanata)	5	52	28.77	6.60

Wyoming, Utah and Nevada. Many of the foothills and valley bottoms which once supported good stands of grasses and native shrubs are now densely covered with this exotic and aggressive annual. Under management and proper use Russian-thistle rapidly disappears and the native plants increase in vigor and density.

d. Wah Wah Valley

From 1880 to 1905 early travelers, ranchers and settlers described Wah Wah Valley as a paradise for livestock. According to their reports, luxuriant mixed stands of white sage and desert grass flourished on the eastern slope of the valley. Cattle weighing from 800 to 1,000 pounds and fat enough to market were taken directly from these ranges and slaughtered during any season of the year. As seen in table 6, this range is now sadly depleted.

Mortality data for the entire Intermountain region is summarized in the accompanying chart which gives for the various ranges the trend of plant numbers. This chart includes data from more than 5,000 sample plots distributed over the winter ranges of the Red Desert and southwestern Wyoming, all of Utah, all of Nevada, and southern Idaho. A classification of the condition of ranges shows that 5 percent of the winter range has not deteriorated to any marked degree. These preserved range areas are located in inaccessible places, long distences from water or in lightly used areas. Seventy-five percent of the ranges are heavily grazed and show considerable depletion and species replacement, and 20 percent of the range is severely depleted showing almost complete transformation of the original plant cover.

The percentage of palatable plants has been reduced materially on heavily and severely grazed ranges. Black sage shows a decrease of 67 to 100 percent on heavily grazed range as compared with only 5 percent on managed ranges. Ricegrass and whitesage show decreases ranging from 27 to 100 percent and 44 to 100 percent respectively on open ranges, whereas the decreases for protected ranges are only 9 and 17 percent, respectively. On depleted ranges, poor forage species such as Russian-thistle, snakeweed, and rabbitbrush show tremendous increases. Russian-thistle was entirely absent on protected range, but comprised 22 percent of the plant cover on heavily used range and practically 100 percent on severely used range, while corresponding values for rabbitbrush were 5 percent, 38 percent and 100 percent, respectively.

e. Ranges Recover Rapidly under Managed Grazing

Under three years of conservative use forage production has almost trebled on the winter range of the Desert Branch Experiment Station in western Millard County, Utah. Table 7 summarizes data on forage yield and plant condition from the managed range in contrast to that from the outside open range subjected to unregulated use. Prior to fencing of the area in 1933 the entire range was given the

Chart 1.

TRENDS IN ACTUAL NUMBERS OF PLANTS ON A PERCENTAGE BASIS ON PROPERLY MANAGED, HEAVILY GRAZED, AND SEVERELY USED WINTER RANGES

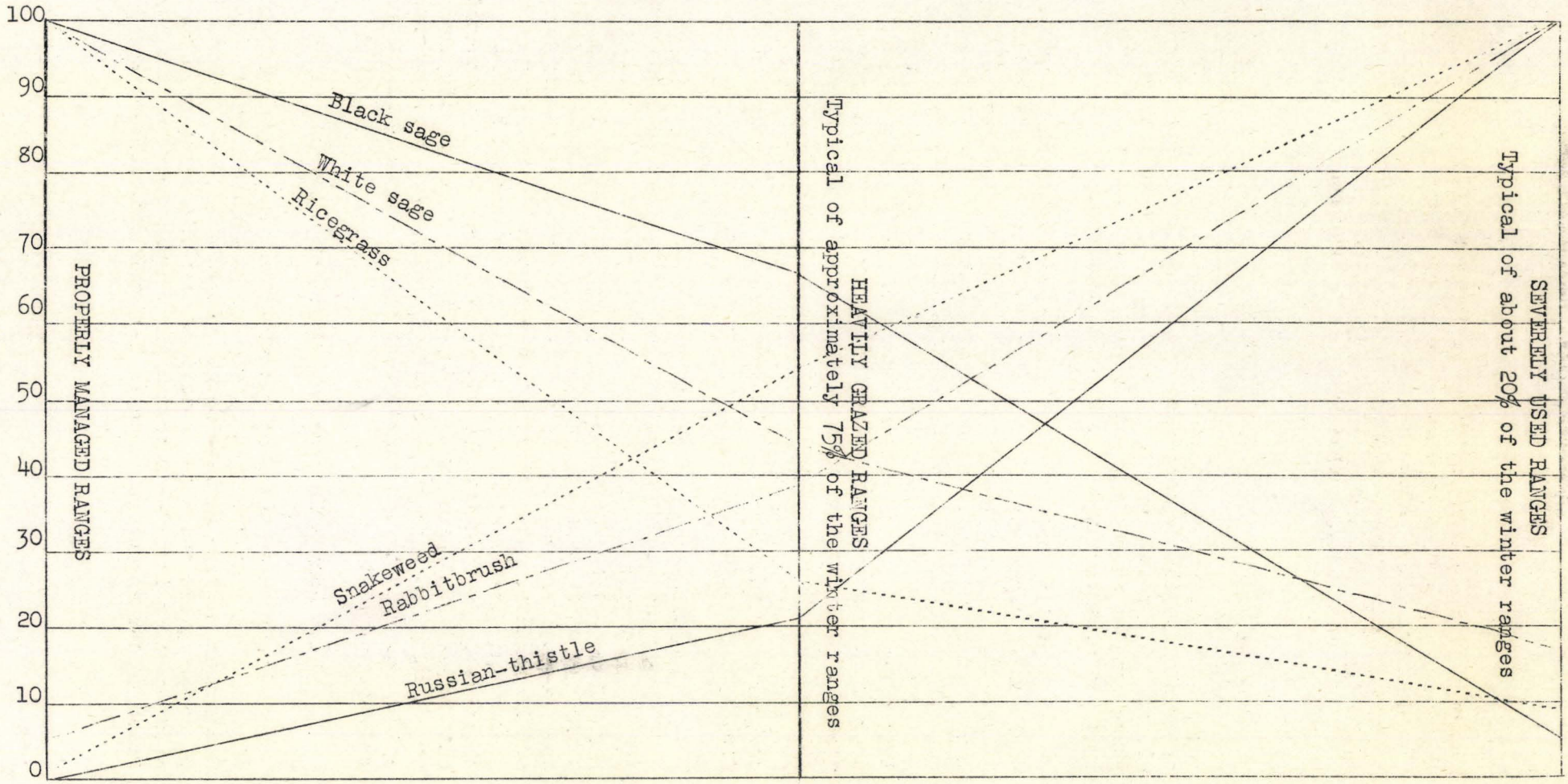

Table 6. - Yield of forage and condition of forage plants on managed and open ranges in Wah Wah Valley.

Species	Oven-dry weight of total plant growth per acre		Oven-dry weight of usable forage per acre	
	Managed Range	Open range	Managed range	Open range
	pounds	pounds	pounds	pounds
Curleygrass (Hilaria)	303.47	137.79	197.26	89.56
Ricegrass (Oryzopsis)	22.14	.07	18.82	.06
Russian-thistle (Salsola)	--	1,369.24	--	342.31
Other weeds	12.84	--	3.21	--
White sage (Eurotia)	589.69	47.08	383.30	30.60
Rabbitbrush (Chrysothamnus)	21.56	31.80	5.39	7.95
Other shrubs	--	2.01	--	--
Total	949.70	1,587.99	607.98	470.48

Species	Dead plants		Plant vigor based on forage produced per 1,000 plants	
	Managed range	Open range	Managed range	Open range
	percent	percent	pounds	pounds
Ricegrass (Oryzopsis)	10	53	50.82	1.47
White sage (Eurotia)	3	64	27.40	4.57
Rabbitbrush (Chrysothamnus)	1	3	41.25	32.10

Table 7. - Yield of forage and condition of forage plants on managed and open ranges at northeast corner of Desert Branch Experimental Range

Species	Oven-dry weight of total plant growth per acre		Oven-dry weight of usable forage per acre	
	Managed range	Typical open range	Managed range	Typical open range
	pounds	pounds	pounds	pounds
Ricegrass (Oryzopsis)	73.39	11.41	62.38	9.70
Other grasses	7.37	-	3.68	-
Snakeweed (Gutierrezia sarothrae)	10.01	9.39	2.00	1.88
Other weeds	61.07	14.94	15.27	3.74
Shadscale (Atriplex confertifolia)	345.83	177.61	155.62	79.92
White sage (Eurotia lanata)	52.49	1.05	34.12	.68
Totals	550.16	214.40	273.07	95.92

Species	Proportion of dead plants: Based on total no. dead & live plants on sample areas		Plant vigor: Based on oven-dry wt. of forage produced per 1,000 plants	
	Managed range	Typical open range	Managed range	Typical open range
	percent	percent	pounds	pounds
Ricegrass (Oryzopsis)	5.00	17.00	33.00	7.00
Snakeweed (Gutierrezia sarothrae)	-	-	17.60	12.31
Shadscale (Atriplex confertifolia)	25.85	29.90	104.00	60.00
White sage (Eurotia lanata)	-	-	29.05	6.05

same high intensity of use and range conditions were similar throughout the area. Since fencing the experiment station, range has been stocked at the rate of approximately two surface acres a month for each sheep, except in 1934-35 when winter precipitation was inadequate to permit full utilization of the forage while on the outside range too heavy use has continued. With protection, the better forage plants on the inside range have increased in number and vigor, while those on the open range have continued to suffer from heavy utilization.

The most striking recovery and improvement has occurred in the most palatable and better forage plants. Ricegrass, which is highly relished by sheep, produced 62 pounds of forage per acre on the managed range as compared to only 10 pounds on the open range.

Seedling production is almost equal on both areas, but the survival of the seedlings following the year of grazing is many times greater on the managed range than on the outside area. This increase in seedling survival is partially responsible for the improvement of the inside range.

Ricegrass has suffered a mortality of 17 percent on the open range and only 5 percent on the managed range. Shadscale has suffered an almost equal mortality on both the inside and outside range, but the remaining live plants on the open range have suffered a considerable loss in vigor, as shown by the fact that they produce only 58 percent as much forage as 1,000 plants as plants on managed ranges. Ricegrass produced 7 pounds of forage per 1,000 plants on the open range in comparison to 33 pounds on the managed range.

Proper management on the inside range has resulted in production of 2.85 times as much forage as is being produced on the adjacent outside range.

f. Complete protection enables native forage to replace weeds

Plants under total protection also make rapid improvement in vigor and cover as is shown by two enclosures in Pine Valley, Utah fenced in 1932. Since the establishment of these areas all the seasons except the summers of 1935 and 1936 have been drought periods, especially 1934, the year of lowest precipitation on record. Hence, the contrast between the inside and outside at Warm Point, Pine Valley and Woods Well is largely the result of protection rather than climatic factors.

g. Warm Point Enclosure

Since the beginning of protection in 1932, ricegrass has increased 166 percent in density on the protected area. Curlygrass, a species of average palatability, withstanding great vicissitudes of grazing, shows no marked change on either the grazed or protected area. White sage, a good forage shrub, shows an increase of 115 percent on the protected area. Shadscale shows a uniform and marked decline on both the grazed and protected areas, largely as a result of drought. Budsage, an

excellent forage, has almost disappeared from the grazed area. Rabbitbrush has increased on the grazed plot and shows a slight decrease on the protected plot. This species is relatively low in palatability and occupies the range apparently only after the better forage species are reduced.

Apparently grazing is largely responsible for the changes in vegetation for the protected area has shown large increases in many plants. Drought also is an important factor in the destruction of a shrub cover; on both areas approximately 30 percent of the shadscale succumbed during the dry seasons of 1932 to 1935. When these severe dry periods are accompanied by excessive grazing, the loss in palatable plants is much greater than that caused by drought alone, and it is therefore important that desert range plants be allowed to build up reserves which will tide them over unfavorable dry seasons.

h. Woods Well Enclosure

In Pine Valley, Utah this enclosure, also established in 1932, today presents a striking contrast to the open ranges. On the outside range Russian-thistle had increased from practically zero to 55 percent of the total cover by 1936. Similarly, rabbitbrush shows an increase of 20 percent on the outside area, but on the inside it has decreased 32 percent. Shadscale shows a 50 percent decrease on the grazed area, whereas on the protected area it shows a decrease of 15 percent. White sage has increased about 30 percent on the protected area, but shows a decrease of 11 percent on the outside area. Ricegrass has almost disappeared from the outside area, while on the inside area it shows an increase of 47 percent. Curlygrass likewise has decreased 50 percent on the outside, but increased about 70 percent on the inside.

4. Artificial Reseeding

More than 1,600 experimental plots have been established on which to conduct artificial reseeding investigations. Before initiating work on the project, the problems to be encountered were studied in detail and plans made for the research required in their solution.

Twenty forage species are being tested at 10 locations in Utah, Nevada, Idaho, and southwestern Wyoming. Fall and spring sowings and the various methods of preparing the seedbed and covering the seed are being tested. Studies are also being made of the physical, chemical, and biological characteristics of the soils to determine their relationships to and needs for the best growth of the better adapted forage species.

These experiments have been designed on the basis of the best modern statistical methods as they apply to this type of research. These include adequate replication and proper randomization of the treatments to guarantee the production of objective and independent results that will not be influenced by such variable factors as soil heterogeneity. The number of experimental plots that have been established at the various work centers is shown in table 8.

Table 8. - The number of experimental plots that have been established at the various work centers for artificial reseeding.

Location of plots	Time of Seeding			Total
	Spring 1936	Fall 1936	Spring 1937	
Wasatch Branch Station	61	143	60	264
Utah State College Farm	37	-	-	37
Boise Branch Station	-	78	54	132
U.S.Sheep Exp. Sta. - Dubois	-	99	63	162
Wells, Nevada	18°	114	-	132
Paradise Valley, Nevada	24°	-	-	24
Lime Canyon, Salt Lake Co.	30°	366	56	452
Huntsville, Utah	-	76	46	122
Kemmerer, Wyoming	13°	-	-	13
Great Basin Branch Station	-	152	104	256
Total	183	1,028	383	1,594

°Plots rather large and primarily of a demonstrational nature.

a. Species which have proved successful in reseeding trials

Common brome (Bromus inermis) when seeded on spring-fall range at the Great Basin Branch Experiment Station increased the range carrying capacity 966 percent over the adjacent outside unseeded area. The seedings were made in plowed furrows three feet apart and covered with soil by the use of a brush drag. Similar seedings of crested wheatgrass (Agropyron cristatum) and mountain brome (Bromus carinatus) increased the carrying capacity of the range 433 and 300 percent, respectively. White sweetclover did not prove successful on this range.

On the summer ranges of higher altitude common brome, mountain brome and slender wheatgrass (Agropyron pauciflorum) particularly have shown promise for reseeding purposes.

Crested wheatgrass was found to grow well and to produce considerable forage on the spring-fall range of the U. S. Sheep Experiment Station at Dubois. It has also been grown successfully on spring-fall ranges and abandoned dry farms in southern Idaho and Utah.

Common rye has been found rather well adapted to many of the range soils and sites that need reseeding. Although it is an annual, there are some indications that it will serve well as a nurse crop in helping other and more permanent grasses to become established. Rye also produces abundant forage for the first year or two while forage grasses are getting started. Rye also will help during this period to protect the range and watersheds against the high run-off of water and soil erosion. Sudan grass has been found in a measure to serve these purposes on sites where it is adapted, especially on the poorer spring-fall ranges where the weather is rather hot and dry and where ordinary forage grasses have great difficulty in growing.

b. Methods which have proved successful

Artificial reseeding has given the best results when the seed has in some way been covered with soil after seeding. Several methods have been tried with varying degrees of success. Trampling in with sheep, and going over the land with a brush drag or harrow have been shown to be effective for this purpose. Favorable results were also obtained from plowing furrows 3 feet apart and on the contour as a means of preparing the land for seeding. Brush dragging the land subsequent to seeding on areas so prepared proved successful.

c. Good soils most favorable for reseeding

Experimental data from Philadelphia Flat in Ephraim Canyon in central Utah show that on areas where the soils are productive, grasses have become successfully established after reseeding but have failed almost completely where the topsoil layer, rich in organic matter, has been removed. For example, on a soil with the original, dark-colored surface horizons still intact and containing 0.60 percent nitrogen, a good stand of Kentucky bluegrass producing abundant forage was

obtained. Not far distant, and where a part of the original surface soil remained, and which contained 0.40 percent nitrogen, was a fair stand of mixed bluegrass, wheatgrass, and weeds. On a similar location, but where the fertile topsoil had been largely removed by erosion, exposing only the raw clay subsoil which contained only 0.21 percent nitrogen, the vegetation consisted almost entirely of weeds which produced only a small amount of forage of poor quality.

PART IV. CURRENT ACCOMPLISHMENTS

B. FOREST AND RANGE INFLUENCES

Forest and range influence investigations during the past year involved a continuation and expansion of studies concerning the closely related problems of water supply and soil conservation on the Boise River watershed in Idaho, and on the steep slopes of the Wasatch Front and the summer range of the Wasatch Plateau in Utah. Some current results of effect on these areas during 1936 are summarized in the following sections:

1. Idaho - Granitic Soils

In the Snake River Valley of Idaho during dry years shortage of irrigation water constitutes a serious problem on a large percentage of the 2,750,000 acres of irrigated lands and prevents the utilization of an additional 1,290,000 acres of irrigable lands for intensive agriculture. The seriousness of the water supply problem in Snake River Valley is accentuated by excessive silt loads caused by accelerated erosion on localized burned areas in the headwaters of tributary streams and on extensive areas of overgrazed foothill range lands. The water supply and erosion problem is especially serious in Boise Valley where the security of investments totaling $55,000,000 is being threatened by water shortages and accelerated erosion on the 1,700,000 -acre Boise River watershed. Supplementing research of recent years on this watershed, additional information was obtained during 1936 concerning factors influencing the yield of water and further effort was made on developing measures for controlling erosion.

a. Progress in Water Cycle Studies

(1) Organic matter increases absorption of surface water by soil. In facilitating the absorption of surface water by the granitic soils of central Idaho, organic matter content is $3\frac{1}{2}$ times as influential as texture and 5 times as influential as moisture content, according to results of 180 tests made on the Boise River watershed during the past field season by means of a specially developed apparatus. The study involved field measurements of absorption rates on selected 1-square-foot plots which were classified on the basis of the organic matter, texture and moisture content of their soils into one of 27 groups as indicated in table 9. The 27 conditions represent the full range of variation of the factors studied in the granitic soil of the region. Statistical analysis of the data indicates that each of the variables have influenced absorption significantly, and that organic matter content is not only the most effective variable, but that it is effective for all textural classes and moisture contents studied.

The ready absorption of surface water by the soil and its delivery to underground channels and reservoirs is of utmost importance in the regulation of streamflow and the maintenance of the maximum

Table 9. The average rate of surface water absorption as influenced by organic matter, texture and moisture content of soil.

Texture 1/	Moisture content 2/	Average absorption rate: Low-organic matter 3/	Medium-organic matter 3/	High-organic matter 3/
		inches-per-hour	inches-per-hour	inches-per-hour
Fine	Dry	1.75	4.22	9.63
	Medium	1.55	3.90	7.44
	Wet	.94	3.13	6.92
Medium	Dry	2.08	5.63	9.89
	Medium	1.54	4.57	8.51
	Wet	1.33	4.11	7.79
Coarse	Dry	2.43	6.88	15.00
	Medium	1.84	6.00	12.25
	Wet	1.50	5.42	10.89

Mean rates for each variable

Organic matter	Low 1.67	Medium 4.86	High 9.81
Texture	Fine 4.38	Medium 5.05	Coarse 6.93
Moisture content	Wet 4.67	Medium 5.29	Dry 6.38

1/ Fine - consisting of more than 40 percent of silt plus clay.
Medium - consisting of 40 to 30 percent silt plus clay.
Coarse - consisting of less than 30 percent silt plus clay.

2/ Dry - water content less than 5 percent moisture holding capacity.
Medium - water content 5 - 20 percent moisture holding capacity.
Wet - water content more than 20 percent moisture holding capacity.

3/ Low - containing less than 2 percent organic matter.
Medium - containing 2 to 5 percent organic matter.
High - containing more than 5 percent.

usable water yields from mountainous watersheds. In a previous study conducted by this station it was shown that range plants greatly increase absorption of surface water because they ramify the soil with their root systems and open up channels which water can follow. The present study shows that plants also have an important indirect effect through building up and maintaining the organic matter content of soils. As a result of these two closely related investigations, there can be no doubt that the restoration and preservation of a dense cover of vegetation is essential for maintaining optimum watershed conditions.

(2) Water cycle studies indicate importance of deep seepage to water yield. The extent to which major streams are sustained by deep seepage as compared to surface and subsurface run-off is indicated by comparative data for the streamflow year ending September 30, 1936 from two 11-acre watersheds and six lysimeters at the Bannock Creek water cycle study area. The lysimeters used in this study are two mil-acre tanks filled with 4 feet of soil from which surface seepage run-off was measured. The larger drainage areas are provided with cut-off walls and instruments for measuring surface and subsurface run-off.

As shown in table 10 the lysimeters yielded run-off of 10.294 surface inches or 43.0 percent of the precipitation received, whereas run-off from the nearby experimental watersheds was only 1.655 and 0.549 inches, or 9.2 and 2.9 percent, respectively, of the precipitation they received. The difference between the run-off from the lysimeters and from the experimental watersheds was due apparently to deep seepage whereby each of the 11-acre drainage areas delivered from 7 to 8 surface inches or approximately 300,000 cubic feet of unmeasured water to deep reservoirs in the bedrock during the year.

Table 10. - Total precipitation and run-off from Bannock Creek lysimeters and 11-acre drainages for hydrologic year September 30, 1936.

Installation	Total annual precipitation : Inches	Total annual run-off : Surface inches:	Percent
Lysimeter battery*	23.96	10.294	43.0
Area "A"	18.01	1.655	9.2
Area "B"	18.94	.549	2.9

* Lysimeters were barren of vegetation during entire year.

The extent of deep seepage and the role of bedrock storage in regulating streamflow has not generally been recognized. The information obtained from the lysimeters and experimental watersheds, together with what is already known regarding the influence of plant cover in controlling surface run-off, clearly indicates not only that deep

seepage plays a very important role in sustaining streamflow but also that watershed management must have as its major objective the maintenance of a plant and soil mantle which will favor the percolation of water into and through the soil.

(3) Improvements completed at the Bannock Creek water cycle study area. During the past season improvements and additions made to the Bannock Creek study area included: (1) the setting out of 50 rain gages to measure precipitation on the two 11-acre watersheds; (2) the installing of 18 interception pans for studying the retention and percolation of water into the soil; and (3) the placing in operation of an intensity rain gage, a triple-pen soil thermograph and an evaporation pan to augment the central climatological station.

b. Progress in Erosion Control

(1) Tests of erosion control by reseeding initiated at new substation. One of the most urgent range-erosion problems in southern Idaho is centered on the spring-fall foothill ranges bordering the Snake River plains. Here, as a result of overgrazing and fire, the original perennial bunchgrasses have been replaced by annual plants of inferior grazing and soil conservation value. During the past summer a range-erosion substation was established in Woodtick Creek on the Arrowrock addition to the Boise National Forest, where accelerated erosion and overgrazing has created a serious threat to the usefulness of that portion of the Boise River drainage for watershed and grazing purposes. At this new sub-station a series of erosion control and range rehabilitation studies were initiated.

Reseeding plots for testing the adaptability of 23 promising range species to the physical condition of this locality and a series of fertility tests for determining the response of native and introduced species to added supplies of nitrogen and phosphorus were established on fenced and open range. Tests with shrubs were also initiated.

To determine the erosion control value of the species used in reseeding, fifty-four 1/200-acre plots were selected and tested by means of a portable erosion apparatus which was used to measure the run-off and erosion resulting from controlled artificial rainstorms. The plots have been reseeded with the most promising species available and their erodibility will again be tested next season when the new plants have become established. The results of this experiment will be of value in planning large scale reseeding operations for the region.

In addition to the plot studies, two of a proposed battery of three 150-acre range watersheds were equipped with flumes as part of an investigation for determining the influence of spring-fall range cover and grazing on water yield and erosion.

(2) Utah - Great Basin Province. The limited water supply and the absolute need for water to sustain agriculture, industry and life itself is one of the most acute problems in the Great Basin province

of Utah. Of equal seriousness in this region are devastating mud-rock flows and the losses of soil due to accelerated run-off and erosion on the mountain slopes from which the water supplies for this region are derived, for these occurrences not only are causing loss of life and damage to property, but they are also rendering ineffective the developments which make possible the storage, diversion and distribution of mountain water. The watershed problems center principally on sore spots at the headwaters of steep canyons along the Wasatch Front and on more extensive areas of depleted summer range-watershed lands on the Wasatch Plateau. Studies of the influence of the plant cover on controlling run-off and erosion on the Wasatch Plateau have been in progress at the Great Basin Branch Station since 1915, and more recently investigations leading toward the control of floods and the regulation of usable water supplies from the steep canyons along the Wasatch Front have been started at the Wasatch Branch Experiment Station. Additional information concerning the control of floods and water yields was obtained during the past season at these two study areas, while considerable progress was also made in the construction of installations for more detailed watershed studies, as is outlined below.

c. Progress in Erosion Control

(1) Contour trenches prevent floods. That floods can be prevented by the contour-trench system was amply demonstrated during the past summer in the history of flood records on the Davis County watershed. On two occasions during the past season mudflows more serious than those of 1923 occurred on four unterraced tributaries of Farmington Canyon whereas the terraced headwaters of Steed, Ford, Davis, Barnard and Parrish Creeks immediately adjacent to Farmington Canyon provided adequate protection against run-off and floods. Rainfall was practically the same on the terraced and unterraced areas as was shown by records from a series of 62 standard and 2 intensity rain gages.

The specific influence of the contour trenches was observed on a 150-acre tributary of Parrish Creek. On this tributary about 50 percent of the area is terraced, 45 percent has a heavy stand of vegetation whereas 5 percent of the area including roads and clearings around buildings is bare.

On July 10 a rainstorm of 1.15 inches occurred over this area, of which amount 0.95 inch fell in the first 15 minutes of the storm. As a result of this intense storm, streamflow increased 160 times over normal, or from 0.10 to 16.00 cubic second-feet for a period of about 20 minutes immediately after the storm.

Observations and measurements revealed that all of the run-off which contributed to the flash flow of the stream came from about 5 percent, or $7\frac{1}{2}$ acres, of the watershed, principally from cleared areas surrounding the camp building and from roads. No surface run-off was contributed from about 45 percent of the area on which there is a dense stand of vegetation, nor was any run-off contributed directly from the remainder or 50 percent of the watershed, which is controlled by the terrace-trench system.

On the 75 acres of controlled watershed area, however, water accumulated in the trenches in an amount that indicated surface run-off was proportionately as great between the terraces as on the roads and cleared areas around the camp buildings. Thus, it is believed that the discharge from this tributary probably would have been ten times greater - and undoubtedly would have caused a serious flood in the valley below - had it not been for the terrace-trenches which held back this surplus water.

(2) Reduction of plant density by overgrazing increases run-off and erosion. That herbaceous plant cover may effectively control erosion and run-off from rainstorms is further substantiated by current results from A and B watersheds at the Great Basin Branch Experiment Station. Reversal of the plant cover density on the two areas, i.e., maintenance of a 40 percent cover on A while reducing that on B to 16 percent, began in 1935. As a result of only one year of plant cover reduction by overgrazing on watershed B which has been maintained at a 40 percent density since 1914, as shown in table 11, the A/B run-off and silt ratios, respectively, have changed from 2.27 to 1.12 and from 2.50 to 1.12.

These data in a striking way substantiate the results obtained from these two watersheds from 1914 to 1929 during which period the herbaceous plant cover on A was changed from 16 to 40 percent while that on B was held at 40 percent. During this period there was a change in the B/A run-off ratio from 4.10 to 1.05 and a change in the B/A silt ratio from 5.42 to 2.48.

The 1936 record, following so short a period of plant reduction by overgrazing on watershed B clearly suggests that run-off and erosion from this area will increase materially when the plant cover is reduced to the proposed minimum of 16 percent.

(3) Soil losses increase with degree of misuse. Soil studies on typical range-watersheds in the Great Basin indicate that soil losses due to accelerated erosion are roughly proportional to the degree and duration of excessive grazing. As shown in table 12, Emigration drainage, unprotected since settlement, has only 13 percent of its area uneroded. Red Butte drainage, completely protected for about 25 years, has 20.4 percent of its land uneroded, and City Creek drainage, completely protected for about 50 years, has 35.8 percent in like condition. Apparently both of these two latter areas suffered from accelerated erosion during approximately the first half century of use and in spite of the degree of protection during the last half century very little, if any, soil improvement has occurred.

The seriousness of these losses is further shown by the fact that the average organic matter content in the surface inch of soil from the City Creek area is 64.8 percent of its uneroded condition whereas in Red Butte and Emigration drainages the average organic matter content is only 56.2 and 49.3 percent respectively of their uneroded soil. Surface one-half foot samples taken at the same sites

Table 11. Periodic annual percent of run-off and volume of eroded material from watersheds A & B, 1915-1936, inclusive, and changes in the A/B plant cover, run-off and silt ratios, Great Basin Station, Ephraim, Utah.

Period	Area "A"			Area "B"			A/B Ratios		
	Plant density percent	Run-off percent#	Eroded material cu.ft.#	Plant density percent	Run-off percent	Eroded material cu.ft.#	Plant density	Run-off	Eroded material
1915-1920	16	10.33	133.82	40	2.52	24.67	0.40	4.10	5.42
1921-1923	16-40	8.74	105.03	40	3.03	37.30	0.70	2.88	2.82
1924-1929	40	5.49	19.15	40	5.23	7.73	1.00	1.05	2.48
1930-1935	40	1.61	11.22	39	0.71	4.48	1.03	2.27	2.50
1936##	40	14.65	190.68	32	13.12	171.46	1.25	1.12	1.12

Based on effective precipitation.

Grazing of area B in 1935 and 1936 followed the effective storms of these years, consequently 1936 data represent results following only 1 year of overgrazing on B.

Table 12 - The extent of accelerated erosion and the influence of treatment on the organic matter content of the surface-inch of soil on drainages near Salt Lake City, Utah. 1/

Drainage	Treatment	Erosion class: No erosion: Frequency	No erosion: Organic matter	Mod. erosion: Frequency	Mod. erosion: Organic matter	Heavy erosion: Frequency	Heavy erosion: Organic matter	Organic matter: Canyon average	Ratio: canyon average / uneroded soil
		percent	percent	percent	percent	percent	percent	percent	
Emigration	90 yrs. no protection Serious burning	13.0	15.2	42.7	9.2	44.3	4.3	7.5	49.3
Red Butte	40 years no protection 25 " partial " 25 " complete " Moderate burning	20.4	12.1	56.7	6.5	22.9	3.2	6.8	56.2
City Creek	40 yrs. no protection 50 " complete " Light burning	35.8	14.2	42.5	8.1	21.6	5.0	9.2	64.8

1/ Note: (a) Surface one-half foot samples show the same relationships.
(b) Correlation coefficients: (1) Organic matter to total nitrogen, 0.982; (2) organic matter to moisture equivalent, 0.915. Based on samples from 1,260 sites.

as the surface inch samples show similar trends, thus further substantiating the above relationships.

(4) Aspen stands efficacious in controlling run-off and erosion. Open stands of aspen when accompanied by heavy litter, but with only a light undercover of herbaceous vegetation, provide adequate control of run-off and erosion during torrential rainstorms on range-watersheds of the Wasatch front. As shown in table 13, an herbaceous undercover of only 14.5 percent density, when accompanied by a heavy litter cover, completely prevented erosion losses during torrential rainstorms and it was 75 times more effective than a 4 percent density of annual weeds and 57 times more effective than an 8 percent density of browse in controlling surface run-off.

The absence of even a trace of silt in the aspen plot tanks was due, no doubt, to the filtering effect of the heavy litter cover. This study, made on the critical Davis County, Utah watershed, suggested that sites which contain considerable aspen, a heavy litter producer, may be grazed normally without serious damage to conditions that control run-off during torrential rainstorms, and that litter is a very effective substitute for herbaceous undercover as an agent of run-off and erosion control on steep slopes.

(5) New flume developed for recording streamflow on steep channel gradients. A Venturi-trapezoidal flume conforming to recognized hydraulic principles was developed during the past year, which is suitable for measurement of debris-laden streamflow, exclusive of mud-rock flows from steep canyon streams, in discharge rates from 0.01 to more than 200 cubic second-feet. This flume meets quite adequately the requirements of a good measuring device for steep debris-laden mountain streams because: (1) by incorporating a 3 percent slope it is self-cleaning under all but mudflow conditions, and (2) mudflows pass over the Venturi section and through the trapezoidal control section with a minimum of damage if the flume is constructed of reinforced concrete.

Developed as a cooperative project between this station and the School of Engineering, Utah State Agricultural College, the structure consists of a broadcrested trapezoidal flume superimposed on a narrow-throated flume applying the Venturi principle. Seven of these flumes have been installed at the Wasatch Branch and Boise Basin Branch Stations, all of which have been calibrated in the hydraulic laboratory at the Utah State Agricultural College by the use of models and the principle of hydraulic similarities.

(6) Soil fertility losses accentuated by erosion. Analysis of soil from 1,391 sample areas in the brush zone of the Wasatch Mountains shows that the soil organic matter and nitrogen content and the moisture-holding capacity are being rapidly altered as a result of accelerated erosion. Data shown in table 14 indicate that soil from heavily eroded sites contains only about one-fourth as much organic matter, and one-third as much nitrogen as soil from adjacent uneroded sites and that the moisture-holding capacity is only one-half as high.

Table 13. - Average plant density and average run-off and silt eroded per square rod (1/160-acre) from Parrish basin, Wasatch Branch Station, as a result of five effective rainstorms which produced a total of 4.38 inches of precipitation, during the summer of 1936.

Type	Plant Density 1/	Ave. run-off per sq. rd.	Eroded material per sq.rd.
	percent	cu. ft.	cu. ft.
Open aspen with heavy litter (Average of four 1/10-acre run-off plots on 22 percent slope)	14.5	0.4660	2/ 0.0000
Annual weed type (Average of six 1/40-acre plots on 22 percent slope)	4.0	34.78	2.86
Browse type 3/ (Average of six 1/40-acre plots on 30 percent slope)	8.1	26.57	2.35

1/ Undercover only
2/ Only clear water reached the tanks
3/ At the present time largely annual weeds due to fires and overgrazing

Soils on moderately eroded sites are also seriously depleted of these valuable properties. In view of the fact that soil development is extremely slow on steep mountain slopes, these losses, which have occurred largely since settlement about 90 years ago, are probably as great as the developmental gains of the last hundred or more years on the moderately eroded soil and are probably equal to developmental gains of the last thousand or more years on the seriously eroded soil. Inasmuch as practically all of the assets of the Great Basin range-watersheds on which valley communities depend, such as regulated streamflow, range forage production, timber and recreational values either directly or indirectly are based on the productivity of the soil on range-watersheds, it is apparent that these losses must be checked if widespread economic and social disturbances, which have already occurred in some localities, are to be averted.

Table 14 - A summary of the average percent organic matter, moisture equivalent and percent nitrogen of the surface-inch of soil on areas in the mountain brush zone of the Wasatch mountains.

Factor studied	Erosion class		
	None	Medium	Heavy
Percent organic matter 1/	14.6	8.3	4.4
Moisture equivalent 1/	39.1	29.2	23.7
Percent total nitrogen 2/	0.58	0.36	0.19

1/ Based on samples from 1,391 sites taken in 18 localities along 25 transect miles.
2/ Based on samples from 180 sites in 3 localities along 5 transect miles.

d. Installation Made to Further Influence Studies.

During the past season considerable time and effort was contributed to the planning and construction of watershed installations. Some of the major accomplishments in this connection are as follows:

(1) Wasatch experimental watersheds. Stream-gaging stations consisting of concrete cut-off walls, Venturi-trapezoidal flumes, recorder houses and automatic waterstage recorders were installed on five of six proposed experimental watersheds with average sizes of more than 100 acres. A physical factor station, including thermographs and intensity rain gages, together with a series of standard rain gages and snow courses to secure an adequate sampling of precipitation by aspect and elevation on each drainage also were installed.

(2) Wasatch streamflow studies. Ten Venturi flumes were installed at 1,000 feet elevational distances on Parrish and Centerville Creeks on the Wasatch Forest in order to study the influence of elevation, aspect, climate, snow cover and other factors on the quality and quantity of streamflow from typical range watershed of the Great Basin.

(3) Wasatch foothill run-off and erosion plots. Twenty-four 1/200-acre plots were surveyed and partial installations were made before winter weather made further installations impossible. This unit which will be completed in March 1937 will be used to study the possibilities of reseeding as a factor in rehabilitation of foothill ranges.

(4) Ogden canyon geophysical stations. Two geophysical stations including 1/200-acre run-off plots, standard rain gages and recording air and soil thermographs were installed on north and south aspects in Ogden canyon to measure the climatic factors associated with soil development, erosion and the contrasting kinds and amounts of plant growth on these aspects.

(5) Watersheds A and B. New tanks of reinforced concrete construction, new tank shelter houses, and new waterstage recorders were installed on watersheds A and B at Great Basin Branch Station. The capacity of the new tanks is about 240 cubic feet per acre as compared with capacities of 122 and 57 cubic feet per acre, respectively, for the old A and B tanks. These enlargements will not only provide adequate storage capacity for sediment under the present system of treatment, but they should be sufficiently large to meet sediment storage needs in the event future systems of treatment result in greatly increased erosion.

PART IV. CURRENT ACCOMPLISHMENTS

C. FOREST MANAGEMENT

Forest management investigations during 1936 were concentrated mainly on three phases of ponderosa pine silviculture, viz: (1) factors affecting seed yield, (2) factors influencing establishment, survival and growth of seedlings, and (3) timber stand improvement. Other work included nursery, direct seeding, planting, root, soil, fire and miscellaneous studies.

1. Seed Studies

The heavy seed crop of 1936 and the availability of CCC assistance for cone collections made possible the investigation of a number of phases of this problem.

a. Cone Maturity

Seasonal trend of the specific gravity of freshly picked ponderosa pine cones was determined and definitely related to cone maturity. Table 15 summarizes the preliminary results of this study.

Table 15. - Specific gravity of freshly picked ponderosa pine cones, Boise Basin, Idaho.

	Sampling date							
	July 7	July 17	July 27	Aug. 6	Aug. 16	Aug. 26	Sept. 5	Sept. 15
Specific gravity of freshly picked cone	0.95	0.92	0.92	0.90	0.86	0.80	0.74	0.67
Percent self-extracted seed after 10-day period of drying in sunlight	0.	0	0	27.46	61.78	82.12	91.44	--
Weight of seed per cone (in grams)	0	0	--	3.40	3.59	4.28	4.39	--

These results indicate rather conclusively that early cone collections may result in material loss in yield due to both immaturity of seed and difficulty of extraction by ordinary means. Additional tests are being conducted to determine the germinative energy and capacity of seed from the different collections, but these preliminary data already indicate that the weight-volume relationship is a reliable index of cone maturity and promises to be of great utility in determining the earliest safe date for cone collection. The mechanics of making specific gravity determinations are so simple that an untrained laborer can make the tests. The specific gravity of freshly picked cones should not exceed a value of about 0.85, or the point at which they begin to float in coal oil or liquids of similar density. Regulation of the specific gravity of test liquids can be accomplished

by varying the proportions of two miscible liquids like alcohol and water. However, this requires some special apparatus, so, for rough determinations, kerosene will suffice as a test liquid for ponderosa pine cones in central Idaho.

b. Cone Yield

Cone yields for trees differing in age, stand position, and altitudinal range were determined. Preliminary results are given in table 16.

Table 16 - Yield and size of ponderosa pine cones, Boise Basin, Idaho.

Description of sample trees	Mean age	Mean number of cones per tree	Mean No. of cones per bu.	Mean length of cone	Mean max. dia.
	years			inches	inches
(1) 2nd Growth Stand (4,000')	46	300	302	3.20	1.74
(2) " " " (5,500')	38	222	251	3.66	1.80
(3) " " Isolated (4,000')	42	586	267	3.50	1.74
(4) " " " (5,500')	36	368	281	3.40	1.75
(5) Virgin scattered (4,500')	150 +	1,407	268	3.78	1.72
(6) " " (5,500')	150 +	1,409	227	3.89	1.90

Substantiating earlier findings, this study showed that open-grown trees bear heavier crops than stand-grown trees, and old open-grown trees bear heavier crops and in general larger cones than do younger trees. Various data from this study may be useful as a guide in future cone collections as well as in designating the proper types of seed trees to include in reserve stands.

c. Seed yield.

Seed yields for the groups of trees listed in table 2 are given in table 17.

Other studies on seed yield included a determination by means of seed traps of the number of seed reaching the ground in a virgin, selectively cut, and an even-aged second growth stand. These numbers are given in table 18.

In general these data show that in a good seed year it is certainly not lack of seed that is responsible for scarcity of pine reproduction. The large numbers indicated for selective cutting areas

Table 17. Yield of ponderosa pine seed, Boise Basin, Idaho.

Description of sample trees	Mean no. of seed per cone	Mean wt. dewinged seed per cone	Mean no. of lbs. of seed per tree	Mean no. of seed per tree	Mean no. of fanned seed per lb.	Mean yield of fanned seed per bu. cones
		grams				pounds
(1) 2nd growth stand (4,000')	64	3.463	2.3	19,700	8,575	2.06
(2) " " " (5,500')	77	4.125	2.0	16,100	8,050	1.90
(3) " " isolated (4,000')	80	4.056	5.2	43,000	8,200	2.39
(4) " " " (5,000')	74	3.571	2.9	24,500	8,450	1.98
(5) Virgin, open grown (4,000')	71	3.916	12.1	101,000	8,350	2.11
(6) Virgin, open grown (5,500')	92	4.298	13.3	118,300	8,875	2.03

Table 18. Seedfall in ponderosa pine stands, Boise Basin, Idaho.

Condition	Average number of sound seed per mil-acre (or number of thousands per acre)	
	Ponderosa pine	Douglas fir
Virgin ponderosa pine type (all exposures)	104.7	3.8
Even-aged second growth, 60 years old (all exposures)	100.5	0
SELECTIVELY CUT STANDS		
Economic selection, medium reserve (west exposure)	356.0	0.7
Economic selection, medium reserve (north exposure)	82.1	92.2
Silvicultural selection, light reserve (south exposure)	304.6	0
All stands	160.5	24.0

are particularly encouraging, as it was formerly suspected that one of the major reasons for lack of subsequent reproduction was insufficient seed supply.

d. Seed Soundness.

Cutting tests were made to determine the apparent viability (i.e. soundness) of seed from various lots. The preliminary results of these tests for the six groups of trees listed in table 2 (vide supra) are given in table 19.

Table 19. - Apparent viability of ponderosa pine seed from Boise Basin, Idaho.

Group	Average soundness*	Range in Soundness
	percent	percent
Number 1	91.5	71 - 98
" 2	89.1	80 - 96
" 3	89.0	65 - 98
" 4	83.8	28 - 98
" 5	83.2	72 - 94
" 6	80.4	40 - 98

* Based on all fully formed seed from 1,750 cones representing 25 trees in each group.

When the laboratory and nursery germination and survival tests have been completed on these lots, an indication of the real significance, if any, of the differences will be obtained.

2. Natural Reproduction

a. Natural Reproduction Factors.

Preliminary results of the study of factors affecting germination and survival show that destruction of ponderosa pine seed and seedlings by rodents and birds is the outstanding cause and may largely account for the notable scarcity of natural reproduction recently observed on cut-over areas. Germination and mortality through the first growing season were recorded for 40,000 seedlings on 216 artificially seeded plots, located on three sites - south slope, north slope, and flat. Half of the plots on each site were protected by a rodent-proof enclosure. Within each group of plots the influence of partial control of the factors

of litter cover, shade, and soil moisture was determined. The general differences due to site and rodent protection are shown in table 20. Tree percentage is an expression of total number of seedlings germinating in proportion to the 1,000 seeds planted on each plot; percentage of survival is at the end of the first season, based upon total germination less the number of seedlings purposely removed.

Table 20. - Germination and survival of ponderosa pine seedlings, Boise Basin, Idaho.

	Aspect			
	South slope	North slope	Flat	All Sites
	percent	percent	percent	percent
Germination (free percentage)				
Rodent-proofed plots	25.5	24.0	15.4	21.6
Unprotected plots	17.1	16.0	13.0	15.4
Survival				
Rodent-proofed plots	45.4	67.7	42.5	51.3
Unprotected plots	2.6	17.8	0.5	7.1

Aside from rodents and birds, the chief causes of seedling mortality were heat (insolation) and damping-off. The data are being analyzed in detail to determine the significance of the results noted above, the differences resulting from the influence of litter and artificial shading and watering, and the relations of seedling development and losses to the measured physical factors of air and soil temperatures, wind movement, humidity, precipitation, and soil moisture on each of the three sites. In general, the variations due to artificial controls were minimized by the relatively favorable soil moisture conditions prevailing on all plots and sites through the 1936 growing season.

b. Transect studies.

Additional information on the survival of natural ponderosa pine and Douglas fir seedlings was obtained by a re-examination of the extensive transects established in 1935. This transect study, the partial results of which were presented in the last annual report, revealed several important facts regarding occurrence and survival of seedlings and pointed the way toward the more intensive factor studies now under way. Although the number of remaining seedlings is now too small to show significant relationships to individual habitat conditions, the general figures on second-year survival given in table 21 are of interest in completing the picture of reproduction mortality and its causes.

Losses during the last period, as in the first season, were relatively heaviest on the virgin forest, medium on the cut-over, and lightest on the burned area. The majority of recent seedling deaths

were ascribed to crushing by snow and other forms of winter kill. Trampling by stock, drought (including plant competition), erosion, rodents, and miscellaneous causes each accounted for the death of a few seedlings. Additional losses of Douglas fir seedlings were roughly proportional to those indicated for pine on each of the areas. The numbers of new or 1936 seedlings found on the same transects were practically negligible; equivalent to 6 per acre on the burned areas, less than 1 per acre in virgin forest, and none on the cut-over area.

Table 21. Survival of natural ponderosa pine seedlings, Boise Basin, Idaho.

Condition	Number of 1935 pine seedlings per acre: Original June, 1935	Surviving October, 1935	Surviving July, 1936	Survival Oct. 1935	Survival July 1936
				%	%
Virgin forest	92	16	5	18	6
Selectively cut forest	47	20	11	43	22
Areas burned in 1934:					
Virgin; heavy burn	1480	810	660	55	45
Virgin; light burn	925	290	185	31	20
Cut-over; heavy burn	15	10	10	67	67
Cut-over; light burn	370	225	175	61	47
Average - burned areas	698	334	258	48	37

3. Timber Stand Improvement

a. Natural Pruning.

Measurements on the progress of natural pruning in ponderosa pine begun in 1935 were completed by an additional intensive study of the branching habit and of the persistence of dead branches. The results of the study show definitely that, if knot-free timber is desired in a reasonably short rotation, it is necessary to resort to artificial pruning. Tables 22 and 23 illustrate this point.

Table 22. - Progress of natural pruning in ponderosa pine stands, Boise Basin, Idaho.

	Age of stand								
	30 yrs	40 yrs 1/	40 yrs 2/	60 yrs 1/	60 Yrs 2/	70 yrs.	80 yrs.	120 yrs.	250 yrs.
Mean height (ft.)	35.8	38.9	39.8	70.4	60.9	84.2	87.0	102.6	141.2
Mean clear ht.(ft.)	1.9	1.4	1.6	1.5	1.8	2.1	5.1	6.7	11.5
Mean ht. to lst green limb (ft.)	10.4	18.8	14.4	31.3	16.6	37.2	37.3	42.9	44.1
Percent of total tree height with green limbs	70.3	51.5	63.4	55.2	72.2	55.8	56.4	58.0	68.8

1/ About normal density

2/ About 60 percent of normal

Stand density of second growth timber does not appear to affect the clear height appreciably, but does influence the rate of dying out of the lower branches. Further data on the persistence of dead limbs in 60-year-old stands are given in table 9.

Table 23. - Persistence of dead limbs in second growth ponderosa pine stands.

Aspect	Height above ground	Mean age of tree	Mean age of dead limbs	Mean length of time limbs have persisted in the dead condition
	feet	years	years	years
North slope	1	60.2	6.8	53.4
	5	53.0	12.1	40.9
	9	47.4	16.7	30.7
	17	39.2	17.4	21.8
Draw	1	53.0	9.5	43.5
	5	47.2	15.0	32.2
	9	42.7	19.8	22.9
	17	35.8	21.4	14.4
South slope	1	51.1	11.5	39.6
	5	43.6	24.6	29.0
	9	37.4	25.4	12.0
	17	29.8	18.0	11.8

It appears that branches or limb stubs may persist in the dead condition for periods exceeding 50 years and still be sufficiently sound to withstand ordinary forces of snow pressure, and the like.

b. Artificial Pruning.

Time studies in a 70-year-old stand were conducted to determine what type of a tree it pays to prune and which one of a number of commercial pruning tools is best suited for second growth ponderosa pine. Preliminary figures are now available and are indicated in table 24.

Table 24 - Average time to prune the first log (17 feet) in 70-years old second growth ponderosa pine, Boise Basin, Idaho.

Average d.b.h. of pruned trees	Aspect					
	South slope			North slope		
	0-7 ft.*	7-17 ft.*	Total	0-7 ft.*	7-17 ft.*	Total
inches	minutes	minutes	minutes	minutes	minutes	minutes
6	2.71	8.07	10.78	1.31	5.80	7.11
10	3.19	12.15	15.34	1.52	6.59	8.11
12	3.50	13.97	17.47	1.64	7.46	9.10
15	3.89	17.14	21.03	1.95	8.63	10.58
20	4.94	30.80	35.74	2.20	9.76	11.96

* The trees were pruned in 2 separate operations, from the ground to 7 feet, from 7 to 17 feet.

It is seen that trees from dense-grown north slope stands take materially less time to prune to 17 feet than do open-grown south slope trees with numerous and large green limbs, and that the time-tree diameter relationship is much more pronounced for the latter. These figures are averages for all tools. Data are available for showing the advantages of various types of tools as well as the influence of size, number, and condition of limbs. A comprehensive report will be prepared as soon as analyses are completed.

c. Thinning and Pruning.

A stand improvement time study was conducted in a second growth, 70-year-old stand during the winter of 1936. Some of the data from this study are tabulated below:

Table 25. Stand improvement operation data for 70-years old second ponderosa pine, Boise Basin, Idaho.

Number of trees per acre in original stand	201
Number of trees removed per acre	88
Number of crop trees selected per acre	39
Number of other than crop trees left per acre	74
Number of man-hours to prune each crop tree	0.60
Felling time per crop tree (man-hours)	0.92
Bucking " " " " " "	0.56
Total time chargeable against each crop tree (man-hours)	2.08
Felling time per tree removed (man-hours)	0.40
Bucking " " " " " "	0.23

The time figures indicate maximum rather than average values due to the fact that the work was done in midwinter and in deep snow which very appreciably slowed down the work. A total of eleven cords of fuelwood per acre was obtained in the thinnings, and this quantity was sold to local residents at 50 cents per cord. If the wood were sold at the current market price for similar products, a substantial reduction of the charge against the crop tree could be realized. Since thinnings were made only around the trees selected for pruning, a relatively good stand of trees was left to provide a second cordwood cut at some future date as well as a number of select unpruned trees for sawtimber in the final harvest.

d. Snow Damage to Thinned Stands

Damage to crop trees from snow breakage was again determined this year, and the results substantiated last year's findings, showing that damage to trees larger than 5 inches d.b.h. was negligible, and that breakage increased with decreasing diameter, excepting the smallest most pliant crop trees. Table 26 shows the cumulative injury percentage to crop trees over a period of two winters.

Table 26. Total percentage of crop trees injured by snow during the first two winters after thinning in ponderosa pine sapling and pole stands, Boise Basin, Idaho.

D.B.H. class	Treatment				
	Check	10-foot Conventional	10-foot crop tree	15-foot Crop tree	20-foot Crop tree
inches	percent	percent	percent	percent	percent
½ - 1.5	7.3	5.3	10.6	10.8	12.7
1.6 - 2.5	9.6	16.7	15.8	17.4	8.9
2.6 - 3.5	4.7	8.6	13.2	12.1	10.8
3.6 - 4.5	2.6	1.3	1.3	1.1	2.9
4.6 - 5.5	0.0	2.5	2.5	0	0
5.6 - 6.5	4.8	0	0	0	0

4. Other Studies

a. Nursery Studies.

The experimental forest nursery was completed this year. First test sowings were made in the middle of June and showed (1) that damping off losses from late sowings appear to be negligible, (2) that drill sowing was more satisfactory than broadcast sowing from the irrigation standpoint, and (3) that rodent depredations constitute one of the major problems in central Idaho nurseries.

b. Direct Seeding.

The first year survival on screened and unprotected ponderosa pine seed spots was 64 percent and 42 percent, respectively.

c. Plantings.

October survival for May, 1936 plantings of 1-F-1 Wind River ponderosa pines ranged from 20 percent to 88 percent with an average of 45.5 percent. In general the first season survival on all sites was considerably better than in either 1934 or 1935.

d. Root Studies.

Differences in root development between natural and planted ponderosa pine seedlings on a recent burn were determined. Table 27 illustrates some of these differences.

Table 27. Root development of natural and planted ponderosa pine seedlings, Elk Creek burn, Boise Basin, Idaho.

Kind of stock	Root depth	Vol. of soil occupied by roots	Amount of soil occupied by roots: Above 12 inches	Amount of soil occupied by roots: Below 12 inches	Vol. of roots
	Inches	cubic inches	percent	percent	cu. in.
Natural 1/	25.6	114	49.4	50.6	.10
Planted 2/	17.7	76	72.8	27.2	.20

1/ Thirteen months after germination of seed.
2/ 2-0 Savenac nursery stock - 13 months after field planting.

A sufficient number of free growing ponderosa pine seedlings from southerly aspects of a cut-over area were dug and measured to furnish a reliable basis for comparing the development of four different age classes of seedlings. Some preliminary figures are indicated below.

Table 28. Top and root development of ponderosa pine seedlings, cut-over area, Boise Basin, Idaho.

	Age of seedling			
	1 yr.	2 yrs.	3 yrs.	4 yrs.
	inches	inches	inches	inches
Average height of top	2.8	4.3	8.1	12.3
Average depth of root	22.4	35.1	54.1	60.7

The facts revealed by these root studies are already proving an important contribution to the understanding of the problems of ponderosa pine, particularly those of artificial regeneration.

e. Soil Studies.

The wilting coefficient of soils from three different aspects was determined by noting the point at which 6-weeks old ponderosa pine seedlings wilted. The study confirmed earlier suspicion that, at least for certain granitic soils, the coefficients derived by dividing the moisture equivalent by the "constant", 1.84, are too high. Results are summarized in the following table:

Table 29. A comparison of soil moisture indices, granitic soils, Boise Basin, Idaho.

Soil moisture index	Aspect		
	South	Flat	North
	percent	percent	percent
"Colloids"	32.68	40.40	38.42
Mechanical wilting coefficient 1/	10.3	11.7	11.4
"Phytometric" wilting coefficient 2/	7.3	7.9	7.5

1/ W.C. = $\frac{\text{Moisture equivalent}}{1.84}$

2/ Total moisture present on wilting date determined by oven-drying to constant weight at 105° C.

f. Fire Studies.

Trend of volatile constituents for one-year-old needles was determined for the month of June. The results in table 30 again confirm the findings of the two previous years, namely, that the percentage of volatile constituents increases with increasing temperature and drought stress.

Table 30. Trend of volatile constituents in current year's foliage of ponderosa pine.

Sampling date	Volatile matter: Lower *	Volatile matter: Upper **	Mean maximum temperature for 10-day period preceding sampling
	percent	percent	Degree Fahrenheit
June 1	105.6	105.1	74.0
June 10	105.6	102.7	68.0
June 20	108.7	107.5	78.8
June 30	130.2	130.0	86.2

* Needles from lower limbs of tree
** Needles from upper limbs of tree

Needles of various moisture content were subjected to high muffle temperatures in an effort to determine their inherent inflammability indices. Table31 indicates some of the results.

Table 31 - Flash point time of ponderosa pine needles subjected to a temperature of 730° F. in a muffle furnace.

Sampling date	Air-dry freshly-fallen dead needles	3-year old green needles	Current year's green needles
	seconds	seconds	seconds
October 3	10.7	38.2	43.0
October 10	11.4	32.8	36.8
October 25	9.8	35.3	37.0

By applying the technique used in arriving at the values in table 31 to green needles throughout the summer, it is expected to find whether or not this increasing moisture content in pine needles (c.f. table 30) actually reflects a less hazardous condition in that type of fuel.

Limited supervision on placement and handling of wood cylinders and duff hygrometers on some central Idaho "fire forests" was given. The 1936 results of wood cylinder and duff hygrometer measurements will be compiled.

g. Snow Measurements.

For the past three winters measurements have been made on two permanent snow courses which pass through a wide variety of slopes, exposures, and timber conditions, including virgin timber, natural openings, and two methods of cutting. The data will afford interyear and inter-cover comparisons and an evaluation of various interactions as well. Table 32 gives gross values of January 15 measurements over a 3-year period and affords a rough comparison of the influence of the four cover conditions on snow accumulation and water content.

Table 32. - Snow depth and water content in relation to forest cover, Bannock and Pine Creek.

Cover	Mean snow depth on January 15			Mean water content on January 15			Mean water content of snow on January 15		
	1935	1936	1937	1935	1936	1937	1935	1936	1937
	in.	in.	in.	in.	in.	in.	%	%	%
Grass (south slope)	18.14	30.30	22.50	3.98	5.88	3.08	21.9	19.1	13.7
Virgin timber	20.27	34.02	26.33	4.55	7.01	3.21	22.4	20.6	12.2
Cut-over (1933)	23.40	38.49	30.93	5.01	8.03	3.66	21.4	20.9	11.8
2nd Growth	18.61	31.64	24.88	5.42	7.39	3.26	25.0	23.4	13.1
Weighted average all types	21.0	34.89	27.37	4.60	7.22	3.37	21.9	20.7	12.3

PART V. PUBLIC CONTACTS

PART V. PUBLIC CONTACTS

In order that the results of forest and range research be incorporated into the plans of utilization of our wildlands it is necessary to acquaint those who use and manage such lands with the contribution research is making. To assure public support for the continuation of research, not only must the users of the resources be informed, but the influential public-spirited citizens as well must understand the problems connected with wildland utilization and the nature of the investigations being conducted for the purpose of solving such problems.

Publication of results of investigation in periodicals and government and other institutional publications is a most necessary means of getting the information widely disseminated. But this alone is not always sufficient to arouse the interest necessary for adoption of our findings or for action in support of our program. Personal contact with research men, observations of results in the field, through field days, inspections and informal visits to the research areas will convince the most skeptical, renew the enthusiasm of our supporters, enlist new friends and further the gospel of conservation.

During the past three years this station has enlarged its field day program to include the Great Basin Branch Station, the Wasatch Branch Station and the Desert Range Station. This program is conducted in cooperation with the Utah Agricultural Extension Service. Besides the scheduled and definitely planned field days, inspection and study trips are planned for special groups, individuals, students of forestry and engineering from colleges and universities, and personnel from the Forest Service and other government and state agencies interested in wildland management. That this program has borne results is evidenced by a change in policy of certain land-managing groups, by active support of our program by influential individuals, groups and institutions and in the case of demonstrated benefits of watershed rehabilitation and management, by a demand from the public for the recognition of important watersheds and inclusion of certain critical areas into the national forest system.

Following is a summary of the efforts of this station, in cooperation with the regional office and the Utah State Agricultural Extension Service to present on the ground the results of our range, reseeding, and influence investigations to the public:

A. FIELD DAY - GREAT BASIN BRANCH

Three hundred and fifty people responded to invitations to visit the Great Basin Branch Station in central Utah, August 7-8, 1936 where the results of research in the fields of reseeding, revegetation, grazing management, plant adaptability, erosion and run-off, were explained and demonstrated by men in charge of the studies. This same group, made up of farmers, livestock men, community and state officials, of government agencies, and a considerable group of government

officials, witnessed an actual range test of a portable rain-making apparatus designed and used to furnish ready information on surface run-off and soil erosion from range lands supporting different types of vegetation.

Five hundred people attended the evening meeting held at the experiment station headquarters where specialists on range use discussed methods of proper range management, the importance of good range, and what the research organization of the Forest Service is doing toward range rehabilitation. William Peterson, Director of the Utah State Agricultural Extension Division, presided.

The composition of the crowd was even more important than the size. Included were officials of the Utah Wool Growers and Cattle Growers Association; the National Woolgrowers Association; staff members from the Utah Agricultural Experiment Station and Extension Service, the University of Utah, and Brigham Young University; supervisors of all national forests in Region 4 on which grazing is important, local representatives of the Soil Conservation Service, federal credit associations, the Resettlement Division, the Biological Survey, and the Division of Grazing, Department of Interior. From beyond the region, the Forest Service was represented by W. R. Chapline, Walt L. Dutton, H. L. Shantz of the Washington office; and by M. W. Talbot and L. J. Palmer of the California and Rocky Mountain Forest & Range Experiment Stations, respectively. The AAA from the Washington office was represented by Bushrod W. Allin, O. V. Wells, and C. M. Nicholson and the Bureau of Agricultural Economics by H. M. Dixon.

Following the close of the second day's field demonstrations members of the Utah Wool Growers and Utah Cattle Growers organizations assembled at the experiment station and held their regular summer meetings.

This field day was held in cooperation with the Utah State Agricultural College Extension Service, and was for the purpose of demonstrating current research findings in proper range management to livestock men and others interested in range use.

1. Secretary Wallace Visits Station

Henry A. Wallace, Secretary of Agriculture and his personal secretary, Mr. Milo Perkins, visited the Great Basin Branch Station in July 1935 with Regional Forester Rutledge, Director Bailey and Mr. Winkler.

Dr. F. G. Elliott of the AAA from Washington, D. C. visited the station on June 30 and July 1, 1936.

B. FIELD DAY - DESERT RANGE BRANCH STATION

More than two hundred men attended the 2-day field program held at the Desert Range Branch Station on October 16 and 17, 1936. The group was made up of influential stockmen; local officials of the

Division of Grazing, Department of Interior; Indian Service grazing men from Utah and Idaho; Soil Conservation Service officials from Utah, Nevada, New Mexico, and California; local representatives of the U.S. Biological Survey; officials of the Bureau of Plant Industry; the president and staff members of the University of Utah; Directors of the Utah Agricultural Experiment Station and Extension Service; staff members of the Utah State Agricultural College, Brigham Young University, and University of Nevada; forestry and soil conservation students from the Utah State Agricultural College; and 41 Forest Service officials from the Regional office in Ogden and the 12 national forests in Utah, Nevada and Idaho on which grazing is a major interest.

An organized tour was made of the 55,000-acre experimental range, as well as ranges on the outside. Stops were made at previously planned points where the work on range rehabilitation, plant succession, proper management, carrying capacity and soils were explained by different staff members, who used portable charts and other displays to amplify the discussion.

In the evening a general meeting was held at the CCC barracks with Director William Peterson of the Utah State Agricultural College Extension Service acting as chairman. During the meeting representatives of the Intermountain Forest and Range Experiment Station outlined the research program of the Desert Range Station and pointed out the importance of the winter range problem, the need of proper range management, and the value of research findings to the livestock industry. Dr. George Thomas, President of the University of Utah, C. W. Petit, Regional Conservator of the Soil Conservation Service, A. D. Molohon of the Taylor Grazing Division also spoke, commending highly the research program and the clear-cut findings so far obtained. They and Director Peterson all stressed the urgent need for the development and application of such range management as will permit the restoration of depleted winter ranges.

In addition to field day, a number of visits to the station were made by men high in the government organization as follows:

Assistant Secretary of Agriculture, M. L. Wilson accompanied by Dr. Blaisdell, a specialist in political science, also of the Secretary's office and Regional Forester R. H. Rutledge visited the station July 18 and 19. A few days later at the AAA meetings at Salt Lake City, Mr. Wilson told the representatives of all the western states that the findings at the Desert Range Station constituted the most significant achievement on range rehabilitation he had seen in the whole West.

Dr. F. F. Elliott, AAA official from the Washington office, visited the station July 1 and 2 and was sufficiently impressed to have three of his staff, Dr. Bushrod Allin, H. M. Dixon and C. M. Nicholson visit the station August 9 and 10.

During August visits were also made by F. G. Carpenter, Chief of the Division of Grazing, Department of Interior, in company with

S. E. Jorgenson, president of the Utah Woolgrowers Association; and by M. W. Talbot, L. J. Palmer, Leon C. Hurtt and Lincoln Ellison of the California, Rocky Mountain, and Northern Rocky Mountain Forest and Range Experiment Stations, respectively.

Neil M. Clark, special writer for the Country Gentleman, accompanied by C. J. Olsen of the Forest Service, Region 4 office, spent on October 17, four hours visiting the experiments and quizzing the men in charge. Mr. Clark gave his impression of the work at the station in a lead article "High Pastures", Country Gentleman, March 1937.

C. WASATCH BRANCH STATION

The work that has been and is being conducted on the watershed of the Wasatch Mountains in the Davis County area by the Intermountain Station and the Wasatch Forest for the prevention of floods and erosion has received nation-wide recognition and has been viewed by hundreds of people ranging in position from CCC boys to the Secretary of Agriculture. This work, located near the main highway, within but 25 miles of either Salt Lake City or Ogden, has been used extensively by the experiment station and the regional office to demonstrate and explain the results of research in range influences and their application to watershed rehabilitation. Following is a listing of individuals and groups that have been conducted over the work at the Wasatch Branch Station during the past two summers:

1. Federal and State Officials

Secretary of Agriculture Henry A. Wallace (3 trips); ECW Director Robert W. Fechner, Vice Director W. C. Lowdermilk, Chief Engineer T. B. Chambers, three regional conservators, engineers, CCC camp superintendents and foremen of the Soil Conservation Service; planning director F. F. Elliott of the AAA; National Resources Committeeman Walter Huber; Chief F. A. Silcox, Associate Chief Earle H. Clapp, Associate Chief ECW L. C. Stockdale, Chief of Experiment Stations James T. Jardine; supervisors and assistants, engineers and rangers of the Forest Service; members of State Planning Boards and consultants; United States senators and representatives from Utah; state legislators, and city and county officials.

2. Forestry School Study Groups

"Show-me" trips for ten college classes numbering 253 students in range, forestry, erosion control and ecology have been made to the Wasatch Branch Station.

3. R-4 Upstream Engineering Conference

In cooperation with the regional office an upstream engineering conference was held on September 8, 9 and 10, 1936 which was attended by 40 supervisors, and assistants, rangers, CCC camp superintendents, foremen and engineers.

Objectives of the conference were to (1) discuss the flood and erosion problems in the Intermountain region, (2) demonstrate contour-trench construction and to inspect the flood and erosion control devices used on the Davis County watershed, and (3) outline methods of flood analysis and report.

Largely as a result of the conference 300 mimeographed copies of contour-trench specifications were distributed to the field and forms for analyzing and reporting floods were developed.

4. Railway Ticket Agents

The station cooperated with the Regional office and the Ogden Chamber of Commerce in conducting 300 railway ticket agents over part of the Ogden River watershed recently added to the Cache Forest. The objectives of the Forest Service in watershed management were explained and very favorably received.

5. Boxelder "Show-Me" Trip

In cooperation with the Cache Forest, a party of 20 Boxelder County citizens, including the Willard Flood Committee, Boxelder County Commissioners, extension specialists and interested citizens, was conducted over the Wasatch Branch Station and the adjacent erosion control projects. Purpose of the trip was to study the nature, and to observe actual construction of the contour-trench systems of flood and erosion control as applied on the Davis County watershed and to determine the feasibility of applying the same control methods to prevent a recurrence of devastating floods from the Willard watershed in northern Utah.

D. WASATCH BRANCH FIELD DAY.

The first Wasatch Branch Station field day was held August 3, 1935 in cooperation with the Wasatch Forest and the Davis County Flood Committee. Visitors, all of whom were specially invited guests, included representative bankers, businessmen and lawyers; Chamber of Commerce, state, county, and city officers; county agents and other extension specialists; range land owners, livestockmen and interested citizens. Guests numbered 110 exclusive of forest officers.

The purpose of the field day was to point out to influential citizens, some of the disastrous results of overgrazing steep range watersheds typical of the Great Basin; to demonstrate the upstream engineering work, principally contour trenching and gully control, being done by the Forest Service to prevent flood run-off and soil erosion from range watersheds; and to show specifically the dependence, either directly or indirectly, of all classes of valley dwellers on regulated flood-free streamflow and sustained forage yield from range-watersheds.

PART VIII. PROJECT SUMMARIES

RR - INT
Management
Summer Range (Wasatch Plateau)

RANGE MANAGEMENT INVESTIGATION

SUMMER RANGE (WASATCH PLATEAU)

Project: The development of methods of range management of high mountain summer range lands to insure the maintenace and improvement of the grazing capacity of the native forage crop in a manner best to meet the requirements of the range itself, of the dependent livestock, and of the related forest land resources.

Character and Scope: This broad project logically breaks down into a number of subprojects, of which the following are under study at the present time.

1. The effect of climate on plant growth.

2. Vegetational readiness and the length of the grazing season on summer range.

3. Natural revegetation as a means of improvement and maintenane of the range.

4. The degree of utilization as a factor in range management.

5. The influence of season, frequency and degree of harvesting on the productivity, revegetation and vigor of range vegetation.

6. The determination of the influence of rodents on summer range lands with a view of excercising control for the improvement of the range.

7. Artificial reseeding of depleted mountain summer range lands.

RR - INT
Management
Summer Range (Wasatch Plateau)
(Climate and Plant Growth)

Subproject 1: The effect of climate on plant growth.

Character and Scope: To determine for the three major elevational and forage type zones of the mountain summer range (1) which of the climatic factors are of primary importance to forage growth; (2) the part climate, and particularly the fluctuations in climate from year to year, play in (a) forage development and production, (b) the outcome of experimental work generally; and (3) the adjustments in range management necessary to meet fluctuations in forage production.

Progress Made: Records of the more important climatic factors have been kept during the main growing season continuously since 1914, and in some instances yearlong in three vegetational (altitudinal) zones on the Wasatch Plateau in Utah. These data have been summarized and submitted for publication. Forage yield and time and rate of growth have been observed since 1924 to corrolate plant growth and forage yield with the climatic factors.

Vicissitudes of climate as they affect both the time and length of grazing season and the quantity of forage produced have long been recognized to play an important role in range management and forage production. Nevertheless, other exigancies have lead to practices of making both range management and livestock handling conform more or less to set calendars of operation. The measuring of the extent of these fluctuations and their influence on time, rate and quantity of forage production, show that variations in climate are so wide as to appear to justify certain elasticity in range management plans or some other provisions to meet them. Total forage production for a season, for example, may vary from as much as 120 percent above the average in one year to 77 percent below the average in another year. Also the time when grazing should begin may vary as much as 47 days earlier in one year as compared to other years.

Plans: The project will be continued along the line of developing facts and information upon which to base range use that will more adequately meet this problem of climatic vicissitudes from the standpoint of the needs both of management of the range and the needs of livestock. Any study involving climate necessarily must be on a long time basis because of the naturally wide variety of conditions to be met. Climatic records also perforce must be continued in order to be able to weight the influence of climate in the outcome of other experimental studies.

Assignment: Raymond Price.

Date of Completion: Indefinite

RR - INT
Management
Summer Range (Wasatch Plateau)

Subproject 2: Vegetational readiness and the length of the grazing season on summer range.

Character and Scope: To determine the time at which livestock may be admitted to the range without injury to the forage from too early use, (2) methods of determining the time of range readiness, (3) the time that grazing should be discontinued in the fall, and (4) the affects of continued early and late use on the vigor and production of range forage plants.

Progress Made: The results obtained prior to 1923 were published in Department Bulletin 1405.

Phenological observations have been made from 1925 to 1932 of the important range plants at varying elevations from year to year. Detailed growth records of individual plants of important forage species have been obtained from the start of growth in the early spring and continuing throughout the season until covered with snow in the fall.

These data have been summarized and submitted for publication.

Plans: Phenological observations will be continued.

Assignment: Raymond Price

Date of Completion: Indefinite

RR - INT
Management
Summer Range (Wasatch Plateau)

Subproject 3: Natural revegetation as a means of improvement and maintenance of the range.

Character and Scope: To determine (1) the most expedient and economical method of natural revegetation of native forage plants, (2) the rate of reestablishment of valuable forage plants on depleted range lands, (3) the role of seed production and germination as a factor in the natural revegetation of range lands, and (4) methods of management of livestock on the range to meet the requirements of the native forage plants for natural revegetation and at the same time meet the feed requirements of the livestock to the fullest degree possible.

Progress Made: Seventy-six quadrats, 71 major plots, and 7 intensively mapped areas have been established since 1914 in the three major vegetational zones on the Wasatch Plateau in central Utah. These plots have been remapped and rechecked at definite intervals to determine the change of the native forage cover on range lands varying in degrees of depletion, erosion and intensity of grazing. Results to 1922 have been published in Departmental Bulletins 791 and 1405.

All of the data obtained up to and including 1935 have been compiled and analysis started.

Seeding habits, seed production, seed dissemination and germination under various conditions of storage, temperature, and moisture relationships for 55 important range species have been determined for four seasons. These data have been completed and submitted for publication.

Plants: The plots will be mapped in accordance with the regular schedule. These plots will be continued for an indefinite period. Analyses will be completed and report submitted.

Assignment: Raymond Price

Date of Completion: Indefinite

RR - INT
Management
Summer Range (Wasatch Plateau)
(Degree of Utilization)

Subproject 4: The degree of utilization as a factor in range management.

Character and Scope: To determine (1) proper degree of utilization, (2) standards for judging utilization, and (3) percentage of good forage which should remain at time of seed maturity each year on ranges where deferred and rotation grazing is not applied to improve or maintain the forage stand.

Progress Made: A pasture was constructed on the high summer range lands of the Wasatch Plateau in 1923 and has been grazed by a small herd of cattle since 1925. Twelve hurdle plots 16 x 16 feet, supplemented by 12 quadrats were placed in this pasture to secure varying degrees of utilization of the important range plants each year. Field work was discontinued in 1932 on the first phase of the study. All data was compiled and a progress report completed.

Plans: The second phase, consisting of enlarged pasture studies, will be initiated.

Assignment: Raymond Price.

Date of Completion: Present phase will be completed in 1937.
Second phase is indefinite.

RR - INT
Management
Summer Range (Wasatch Plateau)
(Season, Frequency and Degree of Harvesting)

Subproject 5: The influence of season, frequency and degree of harvesting on the productivity, revegetation and vigor of range vegetation.

Character and Scope: To determine (1) the effect of harvesting at different seasons, intervals and closeness of cropping upon the vigor revegetation and productivity and carbohydrate accumulation of improtant methods of grazing based on the results to improve and maintain the range, and at the same time obtain the best use of the forage.

Progress Made: The main results of early work, involving 11 species and 20 methods of harvesting, are reported on in Department Bulletin 1405. The project was revised in 1923 to study more critically some of the methods previously tried out, on a plot rather than individual plant basis, supplemented with actual grazing trials. A progress report of the herbaceous clipping has been completed. Partial reports have been completed for the grazing phase and browse clipping. Field work of the carbohydrate study has been completed and a manuscript on the food march phase has been completed and submitted for publication.

Plans: To complete final reports on all phases. The initiation of a new clipping study.

Assignment: Raymond Price.

Probable date of Completion: All of the present phases will be completed in 1937, except the carbohydrate study. The untimely death of Dr. E. C. McCarty, who was cooperating in this study, will delay the final report until 1938.

RR - INT
Management
Summer Range (Wasatch Plateau)
(Biological Investigations)

Subproject 6: The determination of the influence of rodents on summer range lands with a view of exercising control for the improvement of the range.

Character and Scope: To determine (1) population, (2) species, (3) habits, (4) forage consumption, and (5) influence on summer range plants of range rodents with a view of maintaining a proper balance to insure greater forage yields.

Progress Made: Four 40 x 40 feet rodent proofed exclosures were constructed in 1931 in the four main vegetational types. Plots have been established inside and outside the exclosures and mapped at regular intervals. No attempt had been made to determine the population, species, habits, and forage consumption of the rodents since the cooperation with the Biological Survey has temporarily ended.

Plans: It is planned to recheck the established plots as scheduled and continue notes on rodent activity.

Cooperation: Biological Survey

Assignment: Raymond Price (Cooperation with Biological Survey)

Date of Completion: Indefinite.

RR - INT
Management
Summer Range (Wasatch Plateau)
(Artificial Reseeding)

Subproject 7: Artificial reseeding of depleted mountain summer range lands.

Character and Scope: To determine (1) suitable species, (2) site conditions, (3) methods and time of seeding, (4) seed production, (5) methods of grazing during periods of establishment, and (6) economics of improving depleted range by introduction of tame (cultivated) and native forage species on mountain ranges in central Utah where the annual precipitation is from 18 to 30 inches, and the growing season 100 to 120 days in length.

Progress Made: Artificial reseeding trials have been undertaken since 1910 on the Wasatch Plateau in Utah. These trials have been on a small scale and of an empirical nature. A large number of forage species have been tried out at different elevations under various soil conditions, moisture, time of seeding and treatment. The results of the work up to 1927 were published in 1931 in Department Circular 178.

Practically all of the artificial reseeding tests made since 1925 have been in the oak brush zone where the main growing season extends from May 1 to August 31. The sweet clovers, crested wheatgrass, common brome, slender wheatgrass and many-flowered brome were used in most of the tests. These tests involved various methods of tilling the land, covering the seed, and time of sowing. These data were summarized and submitted for publication.

Plans: This subproject has been incorporated with the newly established Artificial Reseeding Project. Future work will be in conjunction with the plans for the main study.

RR - INT
Management
Sagebrush-Wheatgrass

SPRING-FALL RANGE

Project: The management of sagebrush-wheatgrass range.

Character and Scope: To develop methods of range management which will maintain or improve native forage on sagebrush-wheatgrass ranges and at the same time develop its best use for range sheep and cattle production.

The sagebrush-wheatgrass ranges of the region are in heavy demand for spring-fall grazing, and for the most part are far below potential productivity as a result of the injudicious use of the range. They are key lands to range livestock operations and improved methods of management are required to insure economical operation.

The broad project breaks down into several divisions, three of which are under study at the present time. Under these three major subdivisions are included four subprojects:

I. Climatic Studies.

Subrpoject 1 - Effect of Climate on Forage Production

II. Grazing Studies

Subproject 2 - Rotation of Spring Grazing Use

Subproject 3 - Intensity of Spring Grazing Use

III. Induced Plant Succession

Subproject 4 - Effect of Sagebrush Removal by Burning on the Subsequent Forage Production of Sagebrush-wheatgrass Range.

Progress Made:

U. S . Sheep Experiment Station: Range management studies started at the U. S. Sheep Experiment Station in 1923 in cooperation with the Bureau of Animal Industry. Four significant results have been derived from these past studies: (1) that climate is an important factor in annual variation in forage production; (2) that overgrazing in the spring, regardless of whether early or late, is

detrimental; (3) that moderate grazing at a fixed period in the spring is likely to be detrimental; and (4) that a portion of the spring forage growth should be left for fall grazing, since summer and fall growth are too uncertain to be relied upon for fall feed.

Fremont County Burning Study: Studies of sagebrush burning started in Idaho State land leased by Fremont County Woolgrowers Association in 1932 indicate that fires of light intensity will effectively kill sagebrush and have no noticeable effect on soil or vegetation. Heavy burning increases the volume of herbage in wheatgrass (Agropyron dasystachyum) and changes organic content, water-holding capacity, total nitrogen and pH of the soil materially. Moderate intensity burns increase the basel area of grasses, especially wheatgrass the junegrass (Koeleria cristata).

Cooperation: U. S. Sheept Experiment Station of the Bureau of Animal Industry, Fremont County Woolgrowers and State of Idaho.

RR - INT
Management
Sagebrush-Wheatgrass

Subproject: Effect of climate on forage production.

Character and Scope: To determine on sagebrush-wheatgrass ranges (a) which of the more important climatic factors play a part in the variations in forage production, and (b) the part that variations in climate play in forage production and development and the adjustments in present grazing practices necessary to meet those fluctuations.

Progress Made: Forage production varies from 60 percent above to 65 percent below normal with two or more successive deficient years occurring. Similar stages of plant development may vary as much as forty days in subsequent years.

Records of climate are available from 1923 to 1936. Forage yield and plant growth have more or less been closely observed since 1932.

The project was enlarged to include measurements of humidity, evaporation and soil moisture throughout the growing season with the view of developing facts and conclusions more adequately correlated with fluctuation in forage production.

A manuscript has been prepared on the immediate and subsequent effects of the 1934 drought.

Plans: The subproject will be continued as previously planned.

Assignment: George Stewart and J. F. Pechanec.

Date of Completion: Indefinite.

RR - INT
Management
Sagebrush-Wheatgrass

Subproject: Rotation of Grazing Use.

Character and Scope: To determine and develop systems of range management that will maintain or improve sagebrush-wheatgrass ranges. This subproject is divided into two phases: (a) experimental tests in paddocks, and (b) practical tests on a range basis.

Progress Made: Experimental tests in paddocks were started in 1933. Two series of four 60-acre paddocks were set aside for the study of rotation and rotation deferred grazing systems, one series being devoted to each system. The rotation and rotation deferred grazing systems were temporarily suspended for the season of 1936 to develop more reliable standards of carrying capacity for the individual paddocks. The regular system of rotation and rotation-deferred grazing will be resumed in the 1937 grazing season.

Using the results from the 1934 range survey the 23,000-acre range has been divided into four allotments. Each allotment is divided into units. On these four allotments rotation and deferred grazing systems are being tested out on a practical basis.

Plans: The regular system of rotation and rotation-deferred grazing will be resumed in the 1927 grazing season. The practical studies on a range basis where grazing is conducted in the four large allotments will be continued.

Assignment: George Stewart and J. F. Pechanec with Stanley E. Smith of the U.S.S.E.S., Bureau of Animal Industry.

Date of Completion: Indefinite.

RR # INT
Management
Sagebrush-Wheatgrass

Subproject: Intensity of Spring Grazing Use.

Character and Scope: To determine the proper degree of spring use on sagebrush-wheatgrass ranges.

Progress Made: Six 80-acre paddocks have been set aside for the study of intensity of spring grazing. Four of these have been divided equally to obtain replication of grazing use. All paddockss were grazed in the 1936 season during the same period of time and by approximately the same number of sheep to determine the carrying capacity of each in order that grazing standards for each paddock might be established.

Plans: Intensity studies will be initiated in the 1937 grazing season. Six intensites of use will be tested on these paddocks; namely, 6, 8, 10, 12, 14 and 16 sheep-days per acre.

Assignment: George Stewart and J. F. Pechanec.

Date of Completion: Indefinite.

RR - INT
Management
Sagebrush-Wheatgrass

Subproject: Effect of sagebrush removal by burning on the subsequent forage production of sagebrush-wheatgrass range.

Character and Scope: To determine on sagebrush-wheatgrass range where sagebrush is not a true dominate the efficiency of controlled burning in removing the sagebrush and the effect on the soil, vegetation and subsequent forage production.

Progress Made: All intensities of burning were successful in exterminating the sagebrush. Burns of high intensity showed deteriorating effects on the soil and there are some indications that medium burns are also somewhat injurious. Basal area of wheatgrass and of all grass plants occurring on 56 quadrats increased in burns of moderate intensity. Density of wheatgrass increased in direct ratio with intensity of burn. Some grasses, especially Stipas and fescues, were injured by fire.

During 1936 the experimental area was grazed to study the behavior of the burned range under conservative use. These studies indicate that immediate and continuous grazing after burning is undesirable, but that protection following the burn until the next spring gives fair results. Protection during the first fall and the following spring after burning, however, is highly desirable but protection for longer periods are not advantageous. Soil moisture studies and phenological studes are being made in comparable sites on burned and unburned range to determine, if possible, the site difference occurring as the result of the use of fire.

A manuscript giving in detail the effects of controlled burning on the vegetation of sagebrush-wheatgrass range has been submitted for publication.

Plans: This subproject will be continued as outlined. Studies will also be made to determine the relationship of type of growing season to the success of burning. More extensive studies of grazing practice after burning will also be initiated in 1937.

Assignment : George Stewart and J. F. Pechanec.

Date of Completion: Indefinite.

RR - INT
Management
Bunchgrass-Granitic Soils

Project: The management of bunchgrass range on granitic soils to provide maximum grazing use without detriment to range or watershed values.

Character and Scope: To determine (1) the extent, and under what conditions natural revegetation may be relied upon to accomplish necessary range improvement, (2) under what conditions artificial revegetation will be necessary and the best artificial revegetation methods to be employed, and (3) the proper method of grazing, including rate of stocking, class of stock and season of use, to insure continued forage production and watershed protection.

Progress: All of the progress made to date on this project is included in the natural revegetation phases of the problem. A network of 100 meter quadrats and 105 major plots have been established and remapped at yearly or biyearly intervals. During 1936 this series has been augmented by more extensive gridiron surveys of 4 grazed and an equal number of protected areas of from 1 to 100 acres each.

Artificial revegetation studies have been initiated in cooperation with the artificial reseeding project.

Plans: Measurement of the present system of plots, quadrats and gridiron surveys will be continued and the system will be improved as the work progresses. A comprehensive analysis of the data accumlated to date will be undertaken.

Cooperative artificial reseeding studies will be continued and expanded.

An cooperative grazing experiment will be initiated during 1937, if satidfactory arrangements can be made.

Assignment: George Stewart And C. K. Pearse.

Date of Completion: Indefinite.

RR - INT
Management
Desert Shrub Range

DESERT SHRUB RANGE

Project: The development of range management methods for desert shrub winter ranges which will insure the restoration and maintenance of the grazing productivity and promote the best use of these lands as to range, livestock and other forest uses.

Character and Scope: This broad general project logically breaks down into several divisions or subprojects. The following of which are being studied at the present time.

1. The effect of climate on plant growth.

2. Influence of seasonal grazing on plant cover.

3. Degree and intensity of grazing and the influence of plant cover as a factor in determining carrying capacity.

4. Palatability and utilization as influenced by seasonal use, by various sheep herds, plant growth, and climate fluctuations.

5. Natural revegetation and range improvement under grazing management and under total protection.

Subproject 1: The effect of climate on plant growth.

Character and Scope: To determine (1) which of the climatic factors are of primary importance to forage production, and (2) influence of climatic fluctuations on forage production and the adjustment in management necessary to compensate for these variations.

Progress Made: Records of the major climatic factors have been kept since 1933 and plant growths have been taken at weekly intervals throughout the summer growing season. Precipitation on the semi-desert ranges is sporadic and extremely variable and extended drought periods common. Plant growth is also variable. The volume of growth has been found to deviate as much as 300 percent between dry and wet years. The fluctuations in precipitation and the influence on forage production are so wide and extensive that they warrant modified elasticity in the development of permanent range management.

Plans: This subproject will be combined and present set up will be enlarged to include free water surface evaporation and the recording of soil temperature at three depths. This will enable better correlation of plant growth with fluctuation in climate factors.

Assignment: George Stewart and Selar S. Hutchings.

Date of Completion: Indefinite.

Subproject 2: Influence of seasonal grazing on plant cover.

Character and Scope: To determine the influence of fall, winter and spring grazing on the plant cover and to determine the relative seasonal damage by sheep grazing to serve as a basis of making variations in the seasonal stocking of semidesert ranges.

Progress Made: A series of ten 320-acre paddocks have been established. Two are grazed in the fall and winter, two in winter and spring, two in fall and spring, two in the winter, and two in the fall, winter and spring. These studies were begun in 1936 and 1937 and individual sheep weights are maintained to determine the influence on flesh production and conditions of animals.

Plans: This study to be continued.

Duration: Five to 10 years.

Assignment: George Stewart and Selar S. Hutchings.

Subproject 3: Degree and intensity of grazing and the influence of plant cover as a factor in determining carrying capacity.

Character and Scope: To determine the degree of utilization that will permit the recovery of desert shrub ranges and insure their maintenance in perpetuity and to determine the influence of the degree of utilization on the sheep condition as reflected in weight and maintenance of animals.

Progress Made: Six 320-acre paddocks have been established and stocked in 1936 on a graduated scale according to the following sheep-months: 250, 155, 120, 95, 90, and 70. Slight variations were made in stocking to compensate for differences in forage production. The scale of st ocking ranges from heavily overgrazed to very light usage. Individual sheep weights are recorded to determine the influence of the degree of grazing on the condition of the animals.

Plans: This study will be continued.

Duration: Five to 10 years.

Assignment: George Stewart And Selar S. Hutchings.

Subproject 4: Palatability and utilization as influenced by seasonal use, by various sheep herds, plant growth, and climate fluctuations.

Character and Scope: Palatability and utilization of desert range forage varies considerably from year to year as a result of climatic conditions at time of grazing, composition of vegetation, seasonal use and herd prculiarity. Variations in palatability are noticeable between dry and wet years, as well as between spring, fall and winter grazing seasons. Maturity of plants as a result of ample precipitation and good growing conditions materially lowers the palatability of some plants such as white sage and curlygrass, while it increases the palatability of such as shadscale. Snow at the time of grazing also influences palatability. Detailed data are taken on numerous herds throughout the grazing season and notes made as to weather conditions, plant growth and composition.

Plans: This study will be continued.

Duration: Indefinite

Assignment: George Stewart and Selar S. Hutchings

Subproject 5: Natural revegetation and range improvement under grazing management and under total protection.

Character and Scope: To determine (1) the degree and rapidity of recovery and natural revegetation on properly managed and totally protected ranges, (2) the rate of reestablishment and increase in vigor of the better forage plants, and (3) the management methods best adapted to meet the requirements for the production and growth of the plants, which will also serve livestock in the greatest possible degree.

Progress Made: Four experimental range allotments and 10 paddocks and 39 enclosures have been established on which 162 brush plots (5 by 20 feet in size) are intensively mapped. In addition, approximately 4,500 permanent density estimate plots have been established on which plant densities and species-list count data are recorded. These plots are recurrently mapped and estimated at definite intervals to determine the change in plant density and numbers of the various plant species which occurred on grazed and protected ranges.

Seed production, dissemination and germination requirements of the major forage species are being studied to serve as a basis of range management.

Plans: The plots will be mapped, plants counted and density estimates taken at definitely scheduled intervals and progress reports prepared.

Assignment: George Stewart and Selar S. Hutchings

Date of Completion: Indefinite

ARTIFICIAL RESEEDING

Project: Artificial reseeding.

Character and Scope: To determine rehabilitation of the plant cover as influenced by the character and quality of soils on sites where reseeding is required; to speed up revegetation of watersheds and other areas of critical importance; to determine the forage species, whether native, imported or produced by plant-breeding that are best adapted to the various soil types; and to determine the most suitable time and methods of seeding and of subsequent treatment of reseeded areas to obtain the most satisfactory revegetation.

This broad project logically breaks down into a number of subprojects, of which the following are under study at the present time.

1. The relation of forage productivity to the character and quality of range soils.

2. The adaptability of forage plants to the various soil and climatic conditions of the range.

3. The effectiveness and economy of various times and methods of artificially seeding range lands.

4. The germination reactions and peculiarities of range forage species.

5. The increase and production of promising species of range forage plants.

6. Plant breeding of range plants.

Progress Made:

1. Detailed plans were developed for the prosecution of the work under the various phases of this project.

2. Work centers were established and experiments set-up at the following places.

   a. Great Basin Branch Experiment Station - In Ephraim Canyo n and on Wasatch Plateau, in central Utah.

   b. Wasatch Branch Experiment Station - On Davis and Salt Lake County watersheds, in northern Utah.

   c. Wells, Nevada, work center - On lower edge of Ruby Division of the Humboldt National Forest, northeastern Nevada.

   d. Paradise Valley, Nevada, work center - On Lower edge of Santa Rosa Division of the Humboldt National Forest, northwestern Nevada.

   e. Boise Branch Experiment Station - On Boise River watershed near lower edge of Boise National Forest, southwestern Idaho.

   f. U. S. Sheep Experiment Station near Dubois, Idaho, southeastern Idaho.

   g. Utah Agricultural Experiment Station farm near logan, Utah, Northern Utah.

Cooperation: Bureau of Plant Industry on plant breeding, plant physiology, nursery and other related phases of the project; Utah State Agricultural Experiment Station on nursery and breeding phases.

Assignment: George Stewart, R. H, Walker, Ira Clark.

Subproject 1: The relation of forage productivity to the character of range soils.

Character and Scope: To determine the soil characteristics that are favorable or unfavorable to the establishment and production of adaptable and desirable species of forage plants on depleted range lands.

Progress Made: Studies of a general or survey nature are in progress in a broad general way to determine the forage productivity on soils of different characteristics in the vicinity of the various work centers. These studies include an examination of plant growth as affected by the topography, texture, moisture relationships, hydrogen-ion concentration, base exchange capacity, organic matter and nitrogen content, general microbiological status, and other important characteristics. These studies are also being related to the type of vegetation supported on the areas. Greenhouse and field experiments are also being conducted to determine the fertility needs of the principal soil types for the best production of adapted native grass plants.

Plans: As the work progresses it will be developed in greater detail and more along an ecological basis to determine the critical factor or factors that are favorable or unfavorable for the production of desirable forage species on the various range lands.

Assignment: R. H. Walker.

Date of Completion: Indefinite

Subproject 2: The adaptability of forage plants to the various soil and climatic conditions of the range.

Character and Scope: To determine the species of forage plants, particularly the palatable grasses, that are adapted to the different soil and climatic conditions now existing on the range lands of the Intermountain region.

Progress Made: Rather extensive experiments have been set up for the purpose of determining the adaptation of the various species to the climate and soils of the various work centers in the region. Some 20 different species are being tested at 10 places, and a total of 1,594 plots have been laid out and seeded. The majority of these experiments have been designed on the basis of the best modern statistical methods, and they have been laid out with adequate replication and proper randomization of the treatments. A few plots, larger in size and primarily of a demonstrational nature, are neither replicated nor laid out on a statistical basis.

Most of these experiments have been set up on a factorial design; that is, certain factors other than the adaptability of species, such as time of sowing and method of covering the seed are also being tested in the one experiment. The testing of these other factors constitute the work of other subprojects, and will be reported in their proper place.

Plans: According to the design of the experiments outlined above some 400 plots are to be seeded to different varieties in the spring of 1937. These sowings will be made at the appropriate time. It is also planned to make new sowings of a smaller number of selected species each fall and spring for the next few years, in order that seasonal differences may be eliminated from the total variances in the selection of adapted species.

General adaptability of the various species will be studied by examining the experimental plots from time to time to determine the stand of plants produced and their general growth characteristics at the various work centers.

Assignment: George Stewart, R. H. Walker, Ira Clark

Date of Completion: Indefinite

Subproject 3: The effectiveness and economy of various times and methods of artificially reseeding range lands.

Character and Scope: To determine the most feasible method of planting and of covering seed, date of sowing, and other practices involved in the artificially reseeding of range lands.

Progress Made: At the various work centers replicated experiments have been set up for the purpose of determining the best time of year to sow the various species of forage plants. For this purpose some 400 experimental plots were seeded in the fall of 1936 and a similar number will be seeded in the spring of 1937.

In addition to the studies on time of sowing, studies on the desirability or necessity of covering the seed have been injected into practically all of the experimental seedings. In most instances no effort has been made to cover the seed on one-half of the plot, whereas, on the other half of the plot the seed has been covered in some manner soon after sowing. In most of this work the seed was raked into the soil with a common garden rake and with the help of CCC boys. In other instances sheep are to be used to trample in the seed.

Plans: Sowings will be made on those plots designed for spring planting, and the same general line of work started will be continued. Additional plots will be set up and seeded from year to year in order to obtain reliable information as to the proper and best methods and time of year for artificially reseeding range lands.

Assignment: R. H. Walker, Ira Clark

Date of Completion: Indefinite

Subproject 4: The germination reactions and peculiarities of range forage species.

Character and Scope: To determine the germination requirements and characteristics of the various grass and other desirable range forage species.

Progress Made: The work on this subproject is just being started. Tests are being made of the germination characteristics of the various seeds used in the artificial reseeding experiments. Tests are also being conducted in the greenhouse to determine the proper depth of sowing of the different species and of the time required for germination and emergence of the seed above the surface of the soil.

Plans: This work is to be continued along the same general direction and certain phases of it will be extended and studied in as great detail as the need for such work is indicated by the studies now under way.

Assignment: George Stewart and R. H. Walker

Date of Completion: Indefinite

Subproject 5: The increase and production of promising species of range forage plants.

Character and Scope: To increase and produce in larger quantity the seed of such species of range forage plants as may be found desirable and which are either not available on the open market or are too expensive to permit of their use economically in artificial reseeding of range land.

Progress Made: For a part of the work on this subproject cooperative arrangements have been made for the use of approximately 10 acres of privately owned range land near Huntsville, Utah, that formerly had been under cultivation. On this land plots have been sown to some of the more promising grasses for range reseeding for the purpose of developing a seed supply and also of determining the requirements for growing grasses for seed production on a relatively large scale.

A special effort is also being made to obtain seed of as many plants that appear promising for range reseeding purposes as it is possible to do so. These will be sown in nursery plots, where their adaptability and growth habits will be studied and also where additional quantities of seed will be produced where possible.

Plans: The work that has been initiated will be conducted in the same general direction, and extended where it is necessary to further the objectives of the project.

Assignment: George Stewart, R. H. Walker, Ira Clark

Date of Completion: Indefinite

Subproject 6: Plant breeding of range plants (Cooperation, Bureau of Plant Industry).

Character and Scope: To improve the quality and adaptability of range plants and to produce new ones by plant breeding methods.

Progress Made: Work just begun.

Plans and Assignment: By cooperative agreement with the Office of Forage Crops, Bureau of Plant Industry, details of planning and conducting this subproject are assigned to Wesley Keller and Dean F. McAlister, agent for the B. P. I., stationed at the Utah Agricultural Experiment Station, Logan, Utah.

Date of Completion: Indefinite

FOREST AND RANGE INFLUENCES

Bunchgrass-Granitic Soils - Idaho

Project: The influence of plant cover and its use in the bunchgrass type on granitic soils on erosion and streamflow.

Character and Scope: To determine for watersheds of the bunchgrass type on loose granitic soils (1) the causes of erosion; (2) the rate of erosion; (3) the influence of herbaceous cover as affected by grazing use in controlling erosion and regulating run-off; and (4) methods of checking and controlling erosion and maintaining desirable run-off conditions by natural and artificial revegetation and other means. The problem involves the investigation of all the factors, especially those in which plant cover plays a part, that affect the yield and rate of discharge of water from a watershed and the erosion of the soil as a means of determining the amount, kind and regulation of cover that will obtain satisfactory streamflow and erosion control.

Progress:

1. The causes of accelerated erosion on the Boise River watershed as determined by an intensive survey in 1930 have been found to be correlated with overgrazing and other physical and biotic factors.

2. Studies of the rate of erosion are being conducted on a series of profile plots but no significant changes have been observed on these areas as yet.

3. Studies of the influence of plant cover on run-off and erosion and on the absorption of surface water by soils by means of portable apparatus have revealed that the original bunchgrasses and other perennial plants having dense fibrous root systems are many times more effective for controlling erosion and for inducing absorption of water into the soil than taproot species now commonly found on overgrazed areas. Lysimeter and watershed installations have been completed for studying other phases of run-off and erosion relationships.

4. Preliminary efforts on erosion control methods have indicated the measures which offer most promise for rehabilitating eroding range lands and these data are to be used as a basis for proceeding with erosion control studies during the current year.

Plans: In addition to a continuation of studies on run-off and erosion relationships as influenced by plant cover, investigations during the current year are to include intensive efforts on erosion control work. Suitable range watersheds have been selected and partially equipped for this purpose and cooperative arrangements made for proceeding with this work.

Assignment: George M. Craddock and C. K. Pearse.

Date of Completion: Indefinite.

Great Basin - Utah

Project: A study of the influence of plant cover, as modified by grazing, on water yield and erosion, on watershed lands in the Great Basin.

Modification of the plant cover by grazing and other agencies in recent years has resulted in the depletion of desirable range forage and accelerated erosion on the high summer ranges of the Wasatch Plateau, disastrous floods from the steep slopes of the Wasatch Front, and accelerated wind erosion on the floors and foothills of the desert valleys. A full understanding of the natural relationships between the plant cover and run-off and soil erosion is vitally important as a basis for the intelligent protection, management and use of these lands. The project is divided into three subprojects as follows:

Subproject 1

Character and Scope: To determine, on lands typical of the Wasatch Plateau having limestone-clay-shale soil (1) the role of herbaceous vegetation in the regulation of surficial run-off and control of erosion, and (2) the regulation of grazing necessary to maintain adequate cover for watershed protection. The study involves the measurement of cover, soil, slope, precipitation, run-off and erosion on two watersheds of about 10 acres each, the density of the vegetation of which is maintained at a given amount by controlled grazing, and on six permanent run-off plots supporting typical associations of range species.

Progress: Started in 1915 and continued to 1934 under one system of grazing, treatment of the erosion areas A & B has been reversed to check the results of early studies, as published in U.S.D.A. Technical Bulletin 220.

Surface run-off has been measured for two years on the plots established in 1934.

Plans: Records are to be continued on the erosion areas and run-off plots and with some refinement of instrumentation to improve the accuracy of results. Funds permitting, surficial run-off will be measured on typical sites by means of portable apparatus.

Assignment: George W. Craddock and A. R. Croft.

Subproject 2

Character and Scope: To determine, on lands typical of the Wasatch Front having steep brush covered slopes and soils of granite-quartzite-schist origin, the role of vegetation as affected by grazing in the regulation of water yield and control of erosion, and to develop methods for controlling run-off and floods from torrential summer storms and melting snow. The study necessarily involves the isolation and measurement of all the factors that influence water yield and time and rate of stream discharge, such as climate, soil, plant cover including cultural treatment, and erosion control measures.

Progress: The Davis County watershed, consisting of 18,560 acres of steep mountainous land on the Wasatch Forest and directly tributary to 5,120 acres of highly developed valley land, was selected as an experimental area for these studies in 1933. The area has been made accessible by road and temporary quarters have been erected for housing field personnel.

The area has been mapped and inventoried with respect to topography, plant cover and soil, revealing a very high correlation between accelerated erosion and depleted plant cover.

A terrace-trench system of erosion control, involving artificial reseeding and planting, was developed and applied to about 400 acres. This much work was sufficient to control erosion on five of the six canyons comprising the study area. Barrier type flood control structures were installed at the mouths of each canyon.

Twelve 1/40-acre and four 1/10-acre run-off plots have been installed to measure surficial run-off and erosion. Six experimental watersheds of about 100 acres each have been selected to determine the effectiveness of erosion control methods for regulating run-off and controlling erosion under different intensities of grazing. Climatic control has been installed on all watersheds and stream gaging stations have been installed on five of the watersheds.

A Venturi-trapezoidal flume has been designed which is suitable for measurement of debris-laden water on steep slopes.

Equipment has been purchased and sites have been selected for water cycle studies.

Twenty-four 1/200-acre run-off plots are being installed in the foothill zone of the Wasatch Mountain Front to study surface run-off and soil losses as influenced by reseeding practices.

Two geophysical stations, including 1/200-acre run-off plots, soil and air thermographs and standard rain gages have been installed on opposite aspects of Ogden Canyon to study the climatic factors associated with soil formation and erosion phenomena and with plant growth and development as influenced by the climatic differences on these aspects.

Plans: To continue records of climate and run-off on watershed and plot areas. To complete range and soil inventories, and the construction of additional erosion control works, and roads. To locate and equip run-off areas and comparable watersheds with suitable devices for measuring run-off and erosion. To continue studies of the value of water from the watershed, physiographic factors affecting soil formation and erosion, and mudflow histories.

Assignment: Bailey, Craddock, Croft, _____

Date of Completion: Indefinite.

RS - INT
M-1
Ponderosa Pine

PART VIII PROJECT SUMMARIES

Preface to Forest Management Project Summary Statements

Forest management studies at the Intermountain Station are officially designated under an Mc (methods of cutting) project. However, the investigations are of necessity considerably broader in scope than is indicated by this designation. In order to effect a more logical division of investigative activities, the strictly methods-of-cutting project is here reported on as a subproject under a hypothetical functional project -- Ponderosa Pine Silviculture. This makes no allowance for the relative importance of each phase of the work from the standpoint of time and fund expenditures, but gives a clearer picture of the organization set-up. Naturally, subdivisions which are here indicated as phases, minor, or subprojects would in stations having larger silvics divisions be dignified as functional projects of regeneration, protection, mensuration, and the like.

Project: Ponderosa Pine Silviculture. (Silvical Research)

Character and Scope: To determine the best method of managing ponderosa pine forests from the standpoint of growth and quality of products, regeneration, protection, reserve stands, yields of usable water, and the perpetuation of the lumber industry on a sustained and sound economic basis. To accomplish this objective requires (1) thorough investigations of all factors and attendant conditions affecting reproduction and tree growth, (2) a knowledge of factors involved in protection of forests from fire, insects, and disease, and their effects when operative, (3) investigation of past practices on private and public lands as well as field application of such new woods practices as developed either locally or in other region, (4) measurements of factors affecting snow storage and water yield in relation to timber stands, and (5) the determination of silvicultural and economic methods of harvesting the products of the forest on a continuous basis.

RS - INT
Mc
Ponderosa Pine

Subproject: Methods of cutting ponderosa pine.

Character and Scope: To determine the most satisfactory methods of cutting ponderosa pine to insure reserve stands yielding maximum growth and quality products, to insure satisfactory regeneration and to provide for maximum yields of usable water and sustained production of lumber and other products.

Progress in 1936: Four methods of cutting plots on the Payette and Salmon were remeasured, and nearly all established reproduction transects on the experimental forest and elsewhere were reexamined. Compilation of the cut-over area data was continued, but progressed very little due to other urgent work of opportunistic character. Alternate cruise plots on the experimental forest were permanently located. Additional utilization roads were developed.

Plans: (1) Established reproduction plots on cutting plots and virgin stands will be reexamined. (2) The compilation of the national forest cut-over data will be brought to completion and a report prepared. (3) Further efforts will be made to develop the utilization road system on the experimental forest, and to establish a demonstration logging and milling operation on the experimental area.

Assignment: T. E. Maki and E. L. Mowat.

Date of Completion: Indefinite.

Working Plans: (1) Methods of cutting (permanent plots). 1-27-31 supplement of 4-1-33, C. A. Connaughton. (2) Cut-over survey 8-16-32 supplements of 11-20-34, 4-6-35, E. L. Mowat. (3) Experimental forest, preliminary plant 7-1-35, C. A. Fawcett.

RS - INT
Mc - Ponderosa Pine
(Pw-Snow Surveys)

Subproject: The effect of method of cutting in the ponderosa pine region upon the rate of accumulation and melting of winter snows.

Character and Scope: To determine the most desirable crown and ground cover from the standpoint of accumulating and retarding rapid snow melting and to coordinate the watershed values of a forest cover with other forest uses. Pending the initiation of broad forest influence studies in this forest type, this practical and important phase of the question has been carried as a division of the method-of-cutting study since 1931.

Progress in 1936: The results of three years' intensive study of a series of plots near McCall, Idaho were published in 1935. In 1934 the scene of field studies was shifted to the Boise Basin Experimental Forest and the plan modified to include a more representative and extensive sample of central Idaho conditions. Measurements during the past year have been continued on two permanent snow survey courses (340 stations) which pass through a wide variety of slopes, exposures, and timber stand conditions, including virgin timber, natural openings, and two methods of cutting. Some preliminary analyses on the 1935 and 1936 data have been completed.

Plans: Sufficient data on the new snow survey courses will have been obtained by the spring of 1937 to make possible a thorough analysis of the influence of the factors of cover and topography. Acceptable results will be derived and published. Until this analysis is completed it is not known whether the field observations may be discontinued or should be modified or extended to confirm uncertain conclusions or answer further questions.

Assignment: T. W. Maki and E. L. Mowat.

Date of Completion: 1937 or indefinite (see Plans)

Working Plans: Effect of slope, aspect, and crown and ground cover upon snow storage and accumulation. Nov. 26, 1934. C.A. Connaughton.

RS - INT
Mc-Ponderosa Pine
(Mt & Mp)

Subproject: Timber stand improvement.

Character and Scope: To evolve and put into practice for study of growth and for demonstrational purpose, methods of timber stand improvement which are silviculturally and economically feasible in the ponderosa pine type.

Progress in 1936: Studies of both natural and artificial pruning of ponderosa pine were made to determine the economic advisability of the latter practice, which seems to be one of the most promising forms of timber stand improvement work for the employment of CCC or relief labor in this region. A comprehensive time-cost study was made of pruning 800 trees to a height of 17 feet with various types of saws and other tools, involving also the variables of tree size and number and size of green and of dead limbs. Final analysis of the data should provide a fairly definite guide to the size and character of the trees which it pays to prune and the best tools and technique to use.

Snow damage to crop trees on the Bannock Creek thinning plots was again determined.

Two permanent sample plots were established in the second-growth improvement cutting area adjacent to the Boise Basin Branch Station, and additional improvement cuttings are being made by relief labor during the winter.

Plans: Stand improvement cuttings will be continued on a small scale on the experimental forest if emergency labor is available. The data on the pruning study will be analyzed and a report on results prepared for the guidance of forests which may be planning this work. It is planned to extend the field study of pruning methods to obtain more data in younger stands of about 30 to 35 years and of about 6-inch average diameter.

Assignment: T. E. Maki.

Date of Completion: 1937 except for plot observations.

Working plans: (1) Rate of natural pruning in second growth ponderosa pine. June 1936. T. E. Maki. (2) An artificial pruning time study in second growth ponderosa pine. June 1936. T. E. Maki. (3) Report on timber stand improvement. Jan. 4, 1935, T. C. Pender.

RS - INT
Mc - Ponderosa Pine
(Mr - Ponderosa Pine)

Subproject: Regeneration (natural phase)

Character and Scope: To determine factors and conditions affecting natural reproduction from the flower stage to the mature seedling. This involves distinct and yet interrelated phases, namely: (a) the factors pertaining to seed supply, i.e., from the initial flower stages to the fate of the mature seed, (b) factors pertaining to germination and initial establishment, and (c) factors pertaining to subsequent survival and growth. The ultimate aim is to determine the optium conditions for successful regeneration which will serve as the goal to strive for in management practices.

Progress in 1936: An informal study of the cone development from the flower stage to maturity, begun in 1935, was completed. Other phenological observations on ponderosa pine were also made. In the study of factors influencing fate of seed, germination and survival, intensive measurements were made through the season on the series of seeded plots in rodent-proof and in stock-proof exclosures on a north slope, south slope and flat.

Plan: The studies of natural reproduction will continue as a major activity. Pertinent studies of factors affecting seed production and fate of matured seed will be continued. Detailed observations of seedling mortality and growth will be continued on all three exclosures. An attempt will be made to capitalize on the expected large number of seedlings from the heavy seed crop of 1936 by making extensive determinations of the effects of soil, aspect, cover, seed source, etc., on establishment and survival of seedlings in mature, cut-over, and second growth stands.

Assignment: E. L. Mowat.

Date of Completion: Indefinite.

Working Plans: (1) Natural reproduction of ponderosa pine in central Idaho. May 24, 1935. E. L. Mowat.

RS - INT
Mc - Ponderosa Pine
(FA - Ponderosa Pine)

Subproject: Regeneration - artificial (nursery phase)

Character and Scope: To test and develop methods of nursery practice which will result in the production of a form of planting stock giving better field survival at a minimum total cost. The study of field plantations and of root systems have indicated the necessity of developing an improved form of planting stock to insure a reasonable survival. The establishment of two new Forest Service nurseries in Region 4 in 1936 and the necessity for growing a small amount of experimental stock at the branch station have brought up other questions of nursery practice, such as rodent-proofing, shading, mulching, and irrigation, that the experiment station should assist in answering. In order to avoid undue expansion of nursery studies they will be confined in general to those essential to the local production of experimental stock and certain broader problems which cannot be solved as well or better by trial at larger nurseries.

Progress in 1936: The first planting of seed in the new experimental forest nursery was made in June 1936 -- a series of beds to test methods of bird - and rodent-proofing and of surface irrigation as adapted to various forms of row or broadcast seeding. In November a series of beds were planted to test mulches of pine needles, fir twigs, aspen leaves, and burlap, largely from the standpoint of protection of seed against birds.

Plans: The mulch study will be continued through 1937; results should be available within a year, but further tests may be necessary if methods now on trial are all unsatisfactory. Emphasis will also be given to the development by watering control and otherwise of a root system on planting stock which will enable the seedlings to establish themselves more promptly and successfully in the field.

Assignment: T. E. Maki and E. L. Mowat.

Date of Completion: Mulch study - 1937; others - indefinite.

Working plans: (1) The effect of varying amounts of water and season of sowing on ponderosa pine nursery seedling development. Oct. 1936. T. E. Maki. (2) Protective and other effects of various mulches on ponderosa pine seed sown in different seasons. Oct. 1936. T. E. Maki.

RS - INT
Mc - Ponderosa Pine
(Fp - Ponderosa Pine)

Subproject: Regeneration - artificial (seeding and planting phase)

Character and Scope: To determine by study of experimental seedlings and plantings the factors of site, source or stock and treatment responsible for good and poor survival, leading to the development of site selection and planting technique that will insure greater success in reforestation of extensive burn or other lands in central Idaho.

Progress in 1936: The test plantings of 1934 and 1935 were followed by the planting of 2,000 seedlings in May 1936 on the same plots. The 1935 results were subjected to machine compilation, the analysis of which largely confirmed the relations to exposure slope, shade, etc., which were presented in the 1934 report. A small scale test of direct spot seeding in the fall of 1935 was checked for survival periodically through the summer and a report prepared on first season survival. A new test of field planting of seed in screen tubes was initiated in the fall of 1936.

Plans: A comprehensive analysis of all trial plantation data will be made and reported upon, bringing this major phase of the study to a close except for general yearly checks on later survival. In future studies, which are the natural outgrowth of this initial phase, special attention will be given to tests of direct seeding (including rodent protection) and to the development of modified forms of planting stock (see Nursery Practice study) and technique of field planting that will insure better survival on those areas or spots where planting was unsuccessful. In 1937 the direct seeding tests will be followed up and further tests made. Plantations of seedling of transplant stock will be made only on a small scale to test specific new practices, forms of stock, species, and season of planting.

Assignment: T. E. Maki and E. L. Mowat.

Date of Completion: Site relation phase - 1938; direct seeding and other new phases - 1940.

Working Plans: (1) Preliminary plan for Boise Basin burn planting project. March 1934. E. L. Mowat. (2) The effectiveness of screening ponderosa pine seed spots against rodents and birds in different seasons of sowing. October 1936. T. E. Maki.

RS - INT
Mc - Ponderosa Pine

Subproject: Ponderosa pine root systems.

Character and Scope: To determine the morphology of ponderosa pine roots as an aide in reproduction studies, planting studies, and method-of-cutting and timber stand improvement investigations.

Progress in 1936: The analysis of the data on 1-, 2-, and 3-year-old seedlings excavated in 1935 showed such wide variations that in 1936 the study was confined to the root systems of free-growing seedlings on southerly exposures and the form of record was modified to be better adapted to older seedlings. Twenty-four additional seedlings were dug, measured, and photographed to round out the picture of normal development of seedlings up to 3 years old. The roots of seven 4-year-old seedlings were also dug and measured. A special study was made to compare the root form of planted seedlings with that of natural seedlings and a report prepared which will be submitted for publication soon.

Plans: The facts revealed by the study are already proving an important contribution to the understanding of the problems of ponderosa pine, and it will be continued along similar lines into older age classes of trees as rapidly as available time and funds permit. While it would be desirable to complete and close the project as soon as possible, it is somewhat flexible and certain other scheduled work will take precedence in 1937 if there is not time enough for all.

Assignment: T. E. MAki and E. L. Mowat.

Date of Completion: 1939 (?)

Working Plans: (1) Ponderosa pine root studies. March 1935. C. A. Connaughton. (2) A comparison of root development of natural and planted ponderosa pine seedlings on a recent burn. June 1936. T. E. Maki.

RS - INT
Mc - Ponderosa Pine
(Pf - Effects)

Subproject: Fire - Effects in the central Idaho ponderosa pine forests.

Character and Scope: To determine the after-effects of fire in terms of the subsequent growth and mortality of surviving trees, the rate and success of natural regeneration, and the succession of vegetation on burned areas. The original study was initiated in 1932, with the broader object of measuring the nature and extent of all forms of fire damage to the forest. Results were published in 1935 in two major reports, dealing with damage to the stand and with erosion relationships. The remaining phase of the study is a follow-up to determine delayed effects and further changes that will complete the picture of fire influence and aid in the management of burned areas.

Progress in 1936: No formal remeasurements or examinations were made in 1936. Several repeat photographs were taken, which showed chiefly the revegetation of portions of the burned area by a heavy cover of brush and weeds.

Plans: The 5-year remeasurement of ten permanent sample plots is scheduled for 1937; also the complete examination of all reproduction and vegetation transects. A progress report will then be prepared to summarize results to date. A plan has been prepared for a temporary study to determine the increase or decrease of shrubby vegetation under fire protection and the resultant effect upon fire hazard, but it will not be initiated until more time and personnel are available.

Assignment: T. E. Maki and E. L. Mowat.

Date of Completion: Indefinite.

Working Plans: Fire damage from varying intensities of burn in the ponderosa pine type of central Idaho. April 1932. C.A. Connaughton.

RS - INT
Mc - Ponderosa Pine
(Pf - Hazard)

Subproject: Fire studies - hazard phase.

Character and Scope: To assist the Regional Office in the testing and perfection of various devices and schemes, particularly wood cylinders and duff hygrometers, used as measures of fuel moisture and forest fire hazard; to compile and compare results of each measurements.

Progress in 1936: The 1935 results of wood cylinder and duff hygrometer measurements on the "fire forests" of central Idaho were compiled and presented in graphical form for comparison among themselves and with humidity, rainfall, and fire occurrence. Limited supervision was given the placement and handling of these instruments during the field season.

Plans: The 1936 data will be similarly compiled. Recalibration of wood cylinders for the entire Region will be undertaken. The station is under strong pressure from administration to expand this project into a comprehensive study of fire hazard measurement including analysis and correlation with past fire records and an immediate intensive effort to develop a satisfactory index of fire danger, both for the high hazard and low hazard forests of Region 4. Other fire problems, such as rating of fuel types, are also suggested for attention. But until additional personnel and funds are provided, no material expansion of fire studies can be attempted.

Assignment: T. E. Maki and E. L. Mowat.

Date of Completion: Indefinite.

Working Plans: Memoranda of procedure:
9-28-32 C. A. Connaughton
3-11-33 E. L. Mowat

RS - INT
Mc - Ponderosa Pine
(Pf - Hazard)

Subproject: Tree physiology.

Character and Scope: To determine whether dessication of green foliage throughout the summer is related to increase in fire hazard, and if so, to what extent.

Progress in 1936: Additional samples of a 1-year-old pine needle were obtained at 10-day intervals during June to show the early summer trend of volatile content, thus completing a full year's record for needles of this age. Nutrient content of these needles was also determined. A study to determine the relationship between moisture trends and inflammability as measured by flash-point time in a muffle was also initiated.

Plans: A report will be prepared for publication as soon as possible and the study in its present form brought to a close. No further field work is planned until a more fundamental study of tree physiology which would explain these and related phenomena may be undertaken.

Assignment: T. E. Maki.

Date of Completion: 1937.

Working Plans: Seasonal trends in moisture content of ponderosa pine needles. Nov. 1934. T. E. Maki and C. A. Connaughton.

RS - INT
Mc - Ponderosa Pine
(M-1, Soil Studies)

Subproject: Ponderosa pine type soil studies in central Idaho.

Character and Scope: To determine the effect of certain physical, chemical, and biological factors of soil on the rate and success of pine reproduction, and on site quality; to attempt to determine what external characteristics are reliable indicators of the potential productivity of various sites; to classify forested areas according to their potential productivity indices; and in general to build up a body of information which will serve as a guide in the grosser manipulations of forest management practices.

Progress in 1936: Small informal studies were carried on to determine (a) crusting tendencies of surface soils on several aspects in relation to the ease of seedling establishments, (b) wilting coefficients of soils as measured by phytometric and mechanical means, (c) soil moisture and temperature relationships on several aspects, (d) partial physical and chemical analyses of nursery soil as well as soil from natural reproduction exclosures.

Plans: Soil studies will be carried on as the need arises in connection with both artificial and natural regeneration experiments. It is planned to initiate preliminary phases of site studies during the coming year and also to begin studies of site quality changes due to cultural and logging operations and fire.

The analysis of the soil temperature slope data from the study initiated in 1934 will be brought to completion and a report issued. Other studies may be reported on as soon as it is determined whether sufficient data are on hand to answer pertinent questions.

Assignment: Maki and Mowat.

Date of Completion: Indefinite.

Working Plans: (1) The effect of the relative hardness of surface soil on the success of seedling establishment on three different aspects. June 1936. T. E. Maki. (2) The wilting coefficient of granitic soils from three different aspects as measured by phytometric and mechanical means. June 1936. T. E. Maki and E. L. Mowat.

RS - INT
Mc - Ponderosa Pine
(B - Phenology)

Subproject: Phenology of forest trees and selected associated plants of the ponderosa pine type of central Idaho.

Character and Scope: To determine the time and progress of vegetative growth, flowering, fruiting, leaf fall and other phenological events for the common forest trees and certain associated key species of lower vegetation of the Boise Basin Experimental Forest; to correlate these observations and measurements with climatic data; and to develop and encourage the use of this information as an aid or index in growth, reproduction, and other investigations or in practices of forest and range administration.

Progress in 1936: A schedule of observations begun in 1935 was revised and systematized in 1936 to allow of statistical analysis of results. Weekly measurements were made on ten specimens each of two grasses, two herbs, and two shrubs at three elevations. Supplementary general observations were recorded for several other common species. Measurements of current diameter growth of 60 trees (ponderosa pine, Douglas fir, and aspen), and current height growth of 35 saplings (ponderosa pine, Douglas fir, and alpine fir) were made weekly through most of the season.

Plans: Data will be analyzed, correlated with weather records, and results of interest reported. Observations will be continued on a similar scale through 1937 and indefinitely.

Assignment: E. L. Mowat.

Date of Completion: Indefinite.

Working Plans: Memorandum of procedure 3-17-36. Lewis Clark.

RS - INT
Mc - Ponderosa Pine
(Fs - Ponderosa Pine)

Subproject: Ponderosa pine seed studies.

Character and Scope: To develop for ponderosa pine seed a body of information which will serve as a guide in seed collection, extraction and storage practices, and in designation of seed trees for reserve stands. The present studies aim to determine facts and factors of cone and seed ripening, interrelations of cone and seed yield through the various stages of extraction, initial influence of general age class and stand position upon yield and quality of seed and seedling, and the influence of temperature and time of seed storage upon viability. This subproject does not include long time genetical studies nor some questions of seed yield and distribution more directly related to natural reproduction study (q.v.) though it may contribute information of value to both. The present study is tentatively divided into three phases: (1) seed yield, (2) seed storage, and (3) seed physics.

Progress in 1936:

1. Seed yield. The heavy seed crop of 1936 and the availability of CCC assistance for cone collection made possible the investigation of several phases of the problem. Measurements by means of seed traps were made to determine the number of seeds reaching the ground in a virgin, selectively cut, and 60-year-old second growth stand. A study was initiated to determine the relation of age class, tree class, growing space, and location of seed tree to cone size, seed yield, seed viability, and initial character of seedlings. The relations between size and weight of closed and open cones, weight and number of uncleaned and cleaned seed were also determined.

2. Seed storage. A test of seed storage was initiated involving the following variables: (a) Seed source. Two age classes, 3 stand positions, 2 altitudes. (b) Temperatures. Fluctuating and constant; high-low and low. (c) Time. One-half year to 6 years.

3. Seed physics. This phase includes studies determining size and weight of seed as related to viability, moisture relationships in maturing seed, and the like. In this connection, a method using the specific gravity of the cone as an index of seed maturity was developed.

Plans: Results from phases (1) and (3) will be published as soon as analysis is completed. Initial results of phase (2) will be available as soon as germination tests are completed. Nursery tests of the various seed lots will be continued through 1937. Germination tests of seed from the 42 storage samples (phase 2) will be made at least once yearly for a period of several years. Except for data analysis and continuing tests of seed viability, no major work on the subproject is scheduled for 1937. New work will be initiated only as there is a demand for further information on pine seed in this region.

Assignment: T. E. Maki and E. L. Mowat.

Date of Completion: (1) The effect of age, stand position and altitude on yield, soundness and viability of ponderosa pine seed. August 1936. T. E. Maki. (2) Yield and viability of ponderosa pine seed with special reference to Dunning tree class (supplemental plan, natural reproduction study). July 1, 1936. E. L. Mowat. (3) The effect of time and temperature of storage on viability of ponderosa pine seed from different sources. September 1936. T. E. Maki. (4) The specific gravity of the freshly-picked cone as an index of cone and seed maturity. July 1936. T. E. Maki.

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